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Koh et al.

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(45) **Date of Patent: Nov. 7, 2017**

(54) **EXTRACTING READING ORDER TEXT AND SEMANTIC ENTITIES**

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(73) Assignee: **Adobe Systems Incorporated**, San Jose, CA (US)

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(22) Filed: **May 30, 2008**

(65) **Prior Publication Data**

US 2014/0301644 A1 Oct. 9, 2014

(51) **Int. Cl.**
G06F 17/00 (2006.01)
G06K 9/00 (2006.01)

(52) **U.S. Cl.**
CPC *G06K 9/00469* (2013.01)

(58) **Field of Classification Search**
CPC G06F 17/211
USPC 715/247
See application file for complete search history.

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Meunier, J.L. Optimized XY-Cut for Determining a Page Reading Order IEEE Computer Society Proceedings of the 2005 Eight International Conference on Document Analysis and Recognition.
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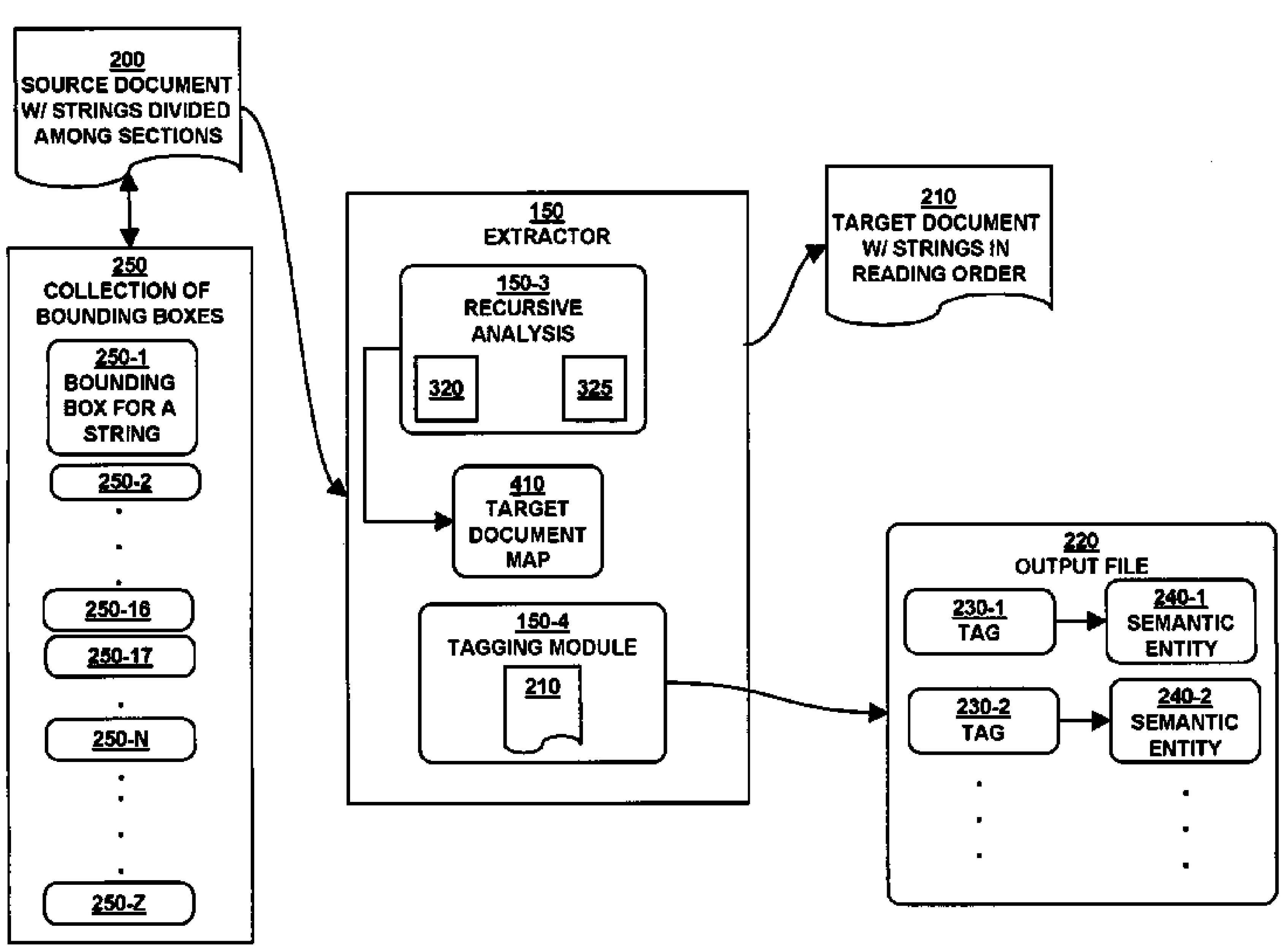
Primary Examiner — Shawn S Joseph
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

Methods and apparatus provide for an Extractor that receives a collection of strings and a bounding box(es) for each string. Each bounding box describes a position of at least a portion of a corresponding string in a source document. The source document includes multiple sections for presenting portions of the collection of strings in the source document. The Extractor arranges the collection of strings according to a reading order that corresponds to a language associated with the collection of strings. Upon arranging the collection of strings according to the reading order, the Extractor collects semantic entities from a target document that has the collection of strings ordered according to the reading order. For each collected semantic entity, the Extractor tags the collected semantic entity with a tag that describes a category of content that corresponds to a logical section of the target document from which the semantic entity was extracted.

17 Claims, 20 Drawing Sheets



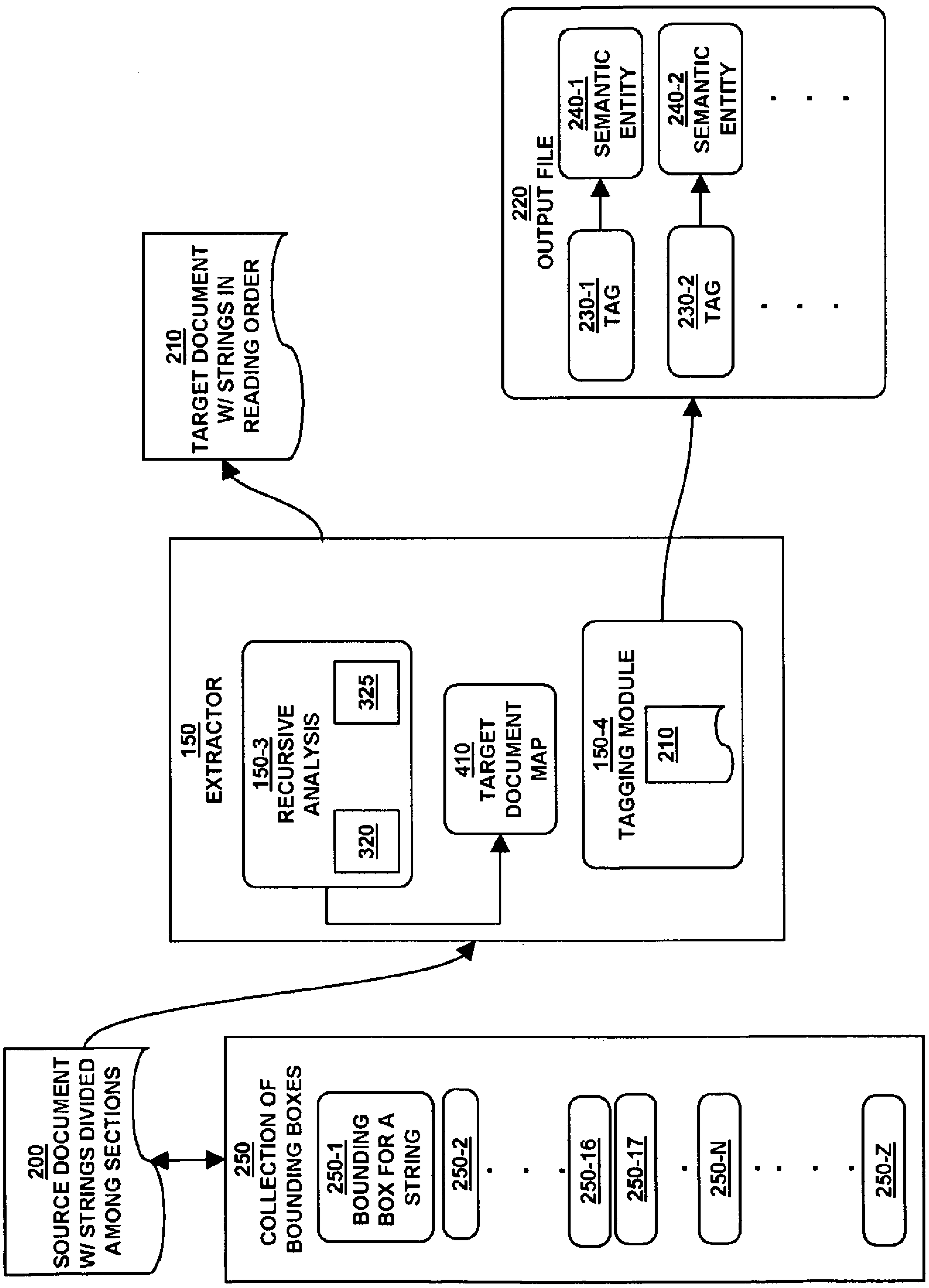

200 SOURCE DOCUMENT W/ STRINGS DIVIDED AMONG SECTIONS
250 COLLECTION OF BOUNDING BOXES
250-1 BOUNDING BOX FOR A STRING
250-2
250-16
250-17
250-N
250-Z
150 EXTRACTOR
150-3 RECURSIVE ANALYSIS
320
325
410 TARGET DOCUMENT MAP
150-4 TAGGING MODULE
210
210 TARGET DOCUMENT W/ STRINGS IN READING ORDER
220 OUTPUT FILE
230-1 TAG
240-1 SEMANTIC ENTITY
230-2 TAG
240-2 SEMANTIC ENTITY

FIG. 1

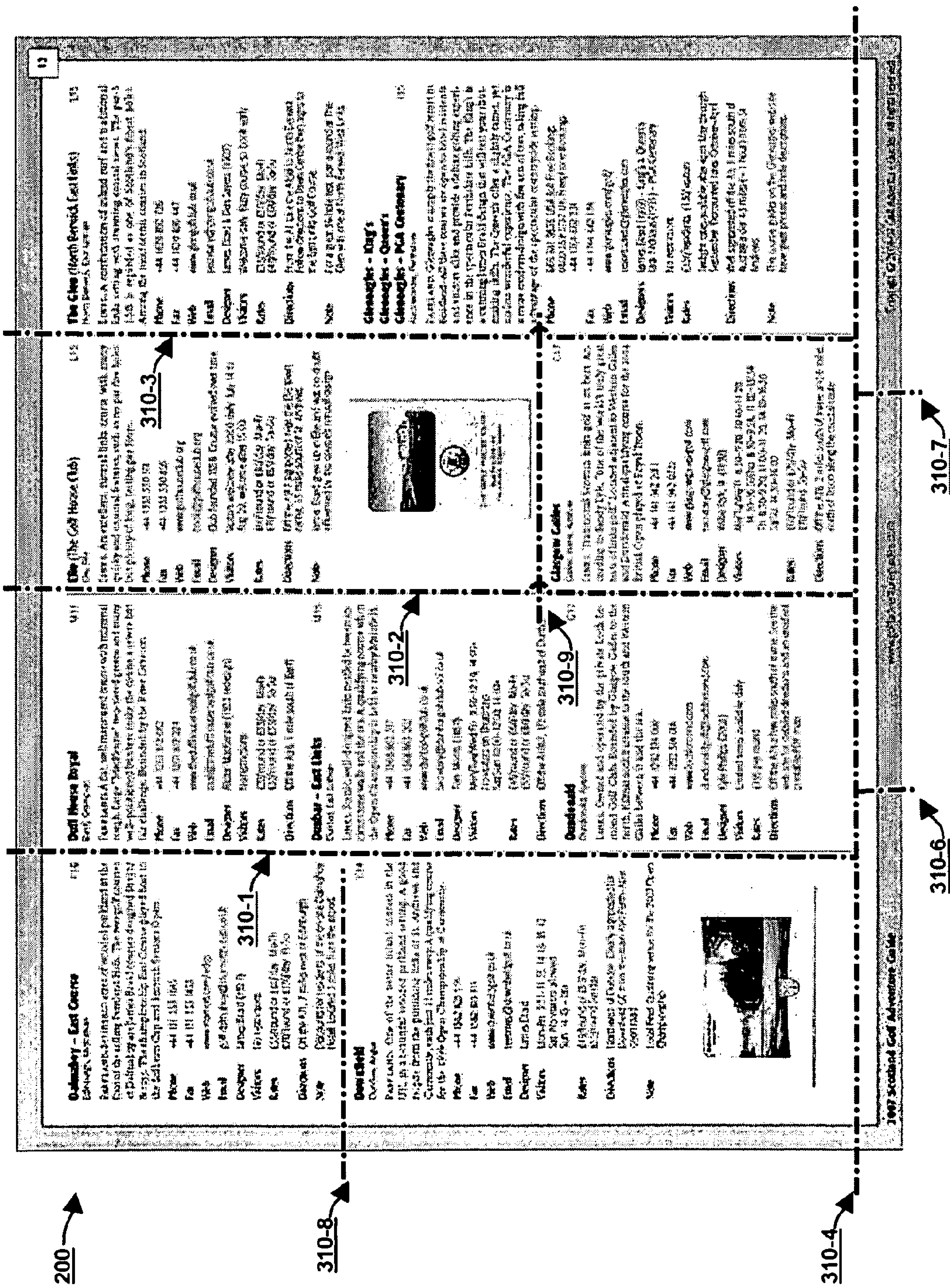


FIG. 2

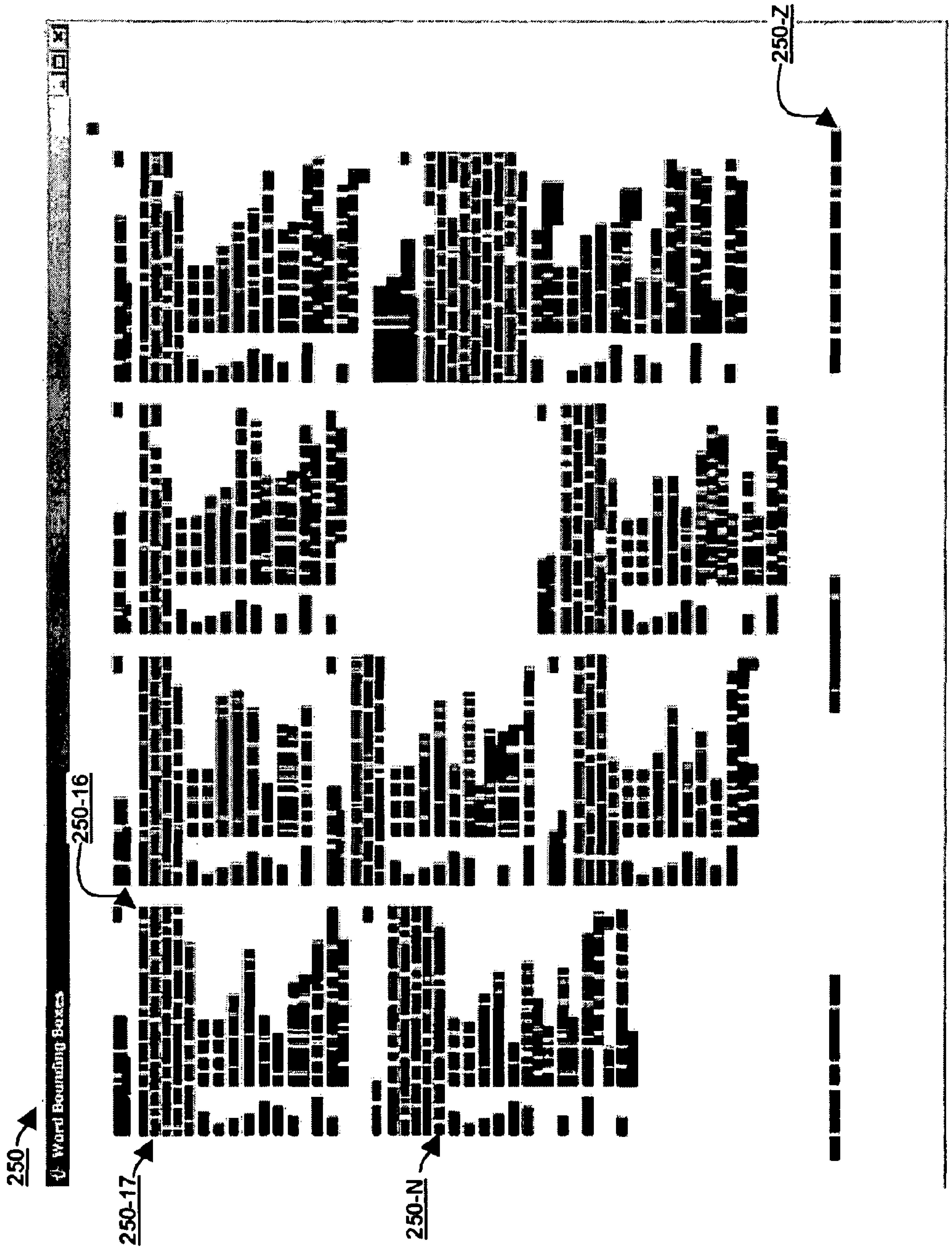


FIG. 3

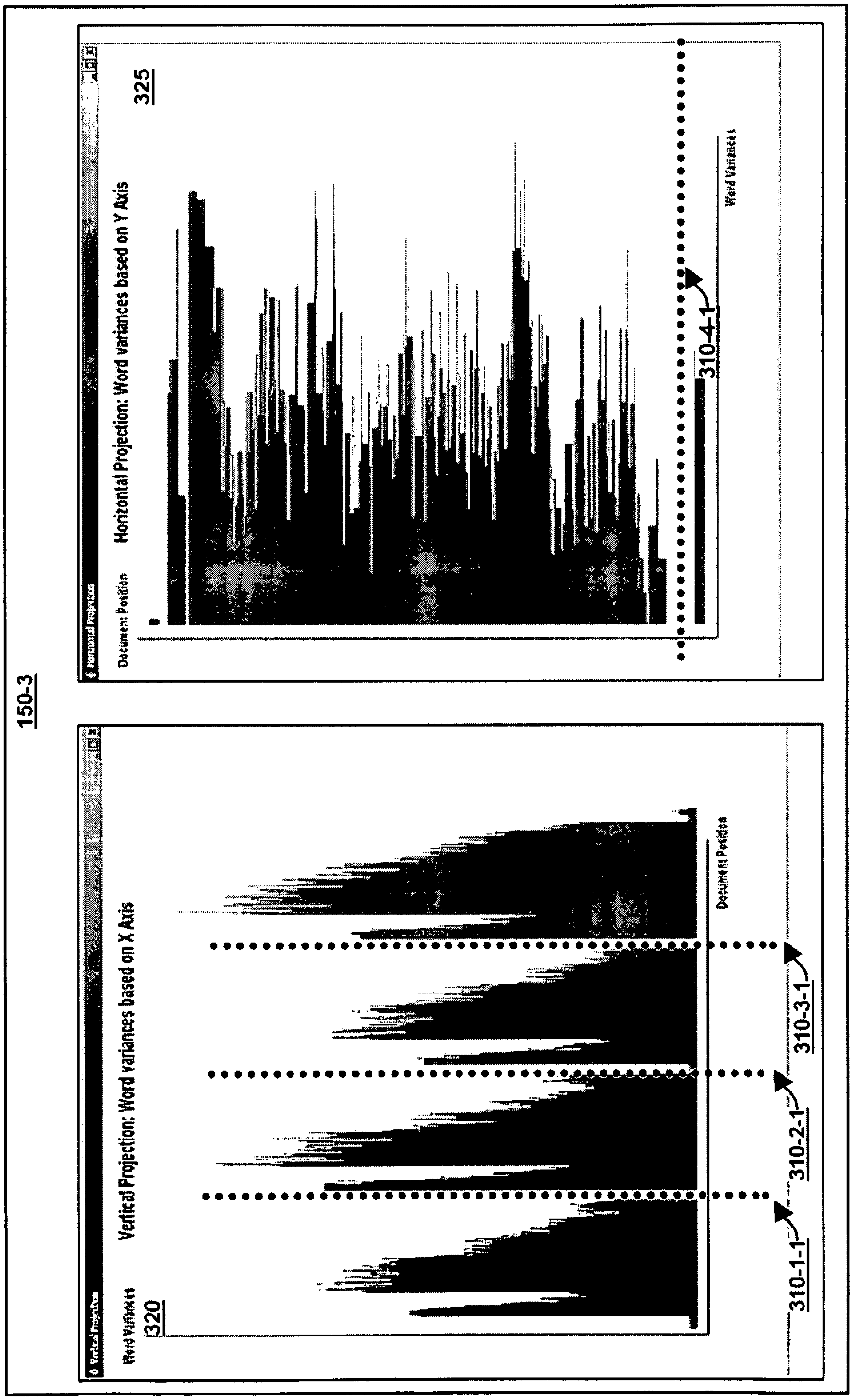

150-3
320
Vertical Projection: Word variances based on X Axis
Word Variances
Document Position
310-1-1
310-2-1
310-3-1
325
Horizontal Projection: Word variances based on Y Axis
Document Position
Word Variances
310-4-1

FIG. 4

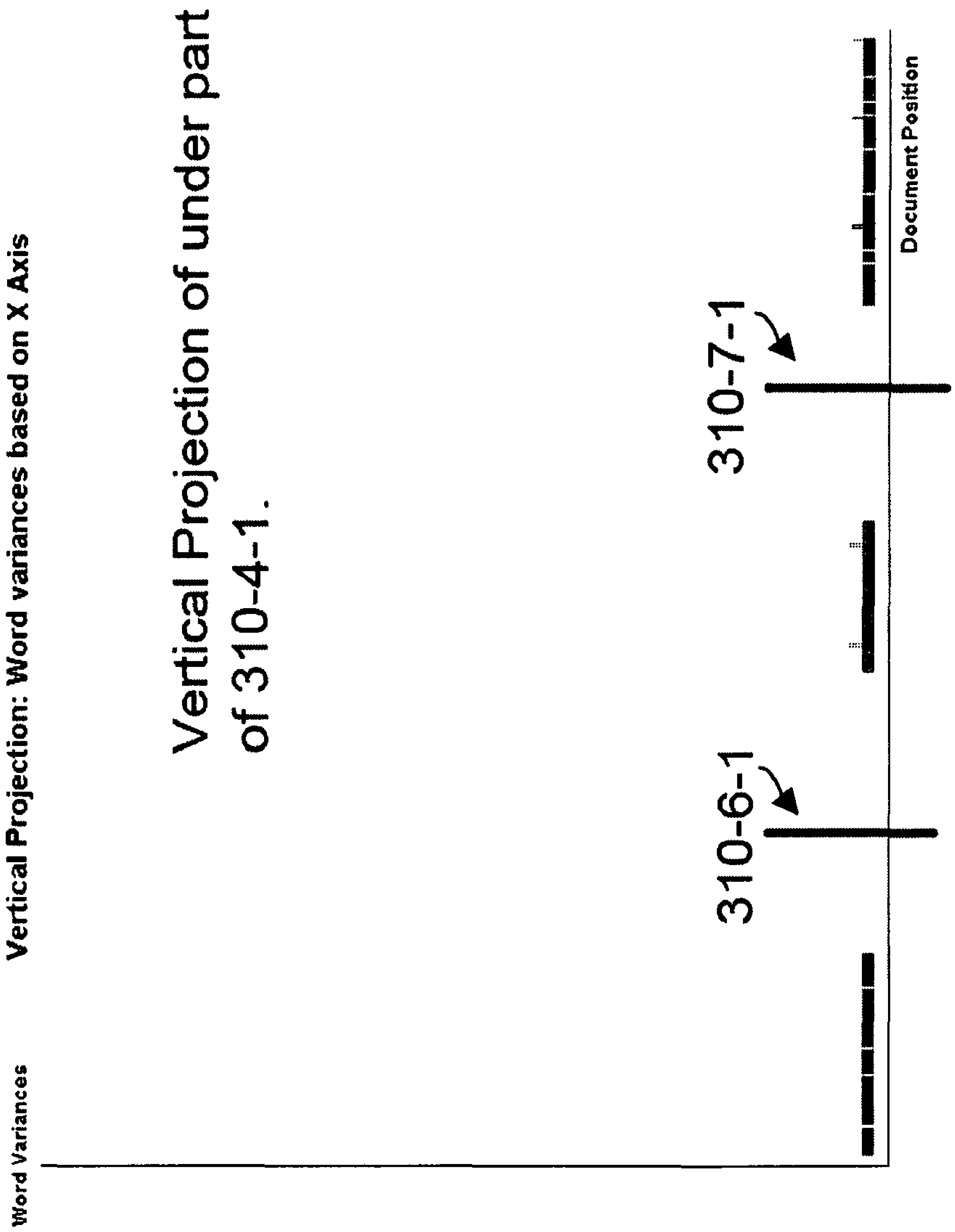

Vertical Projection: Word variances based on X Axis
Vertical Projection of under part of 310-4-1.
Word Variances
Document Position
310-6-1
310-7-1

FIG. 5

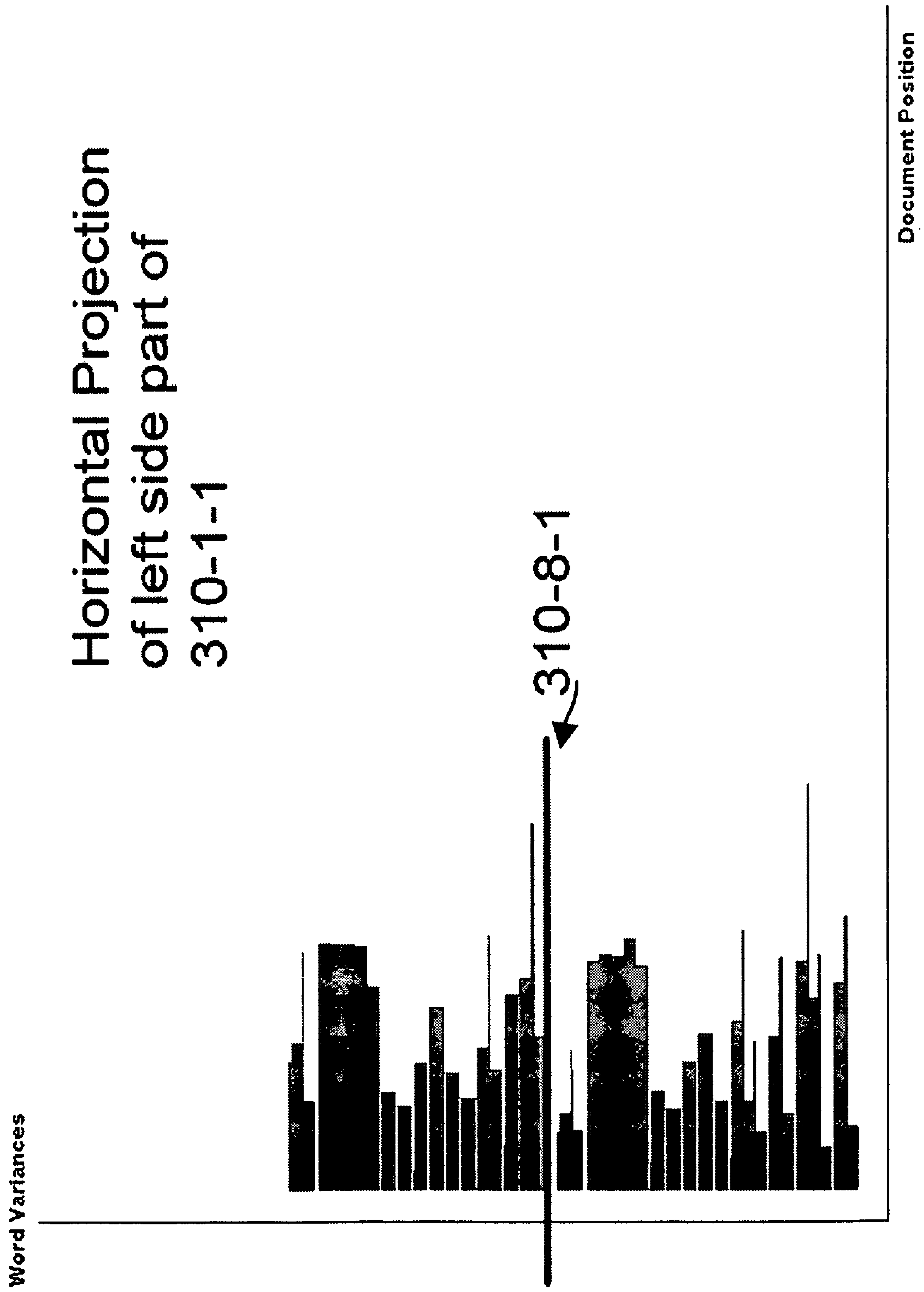

Horizontal Projection
of left side part of
310-1-1
310-8-1
Word Variances
Document Position

FIG. 6

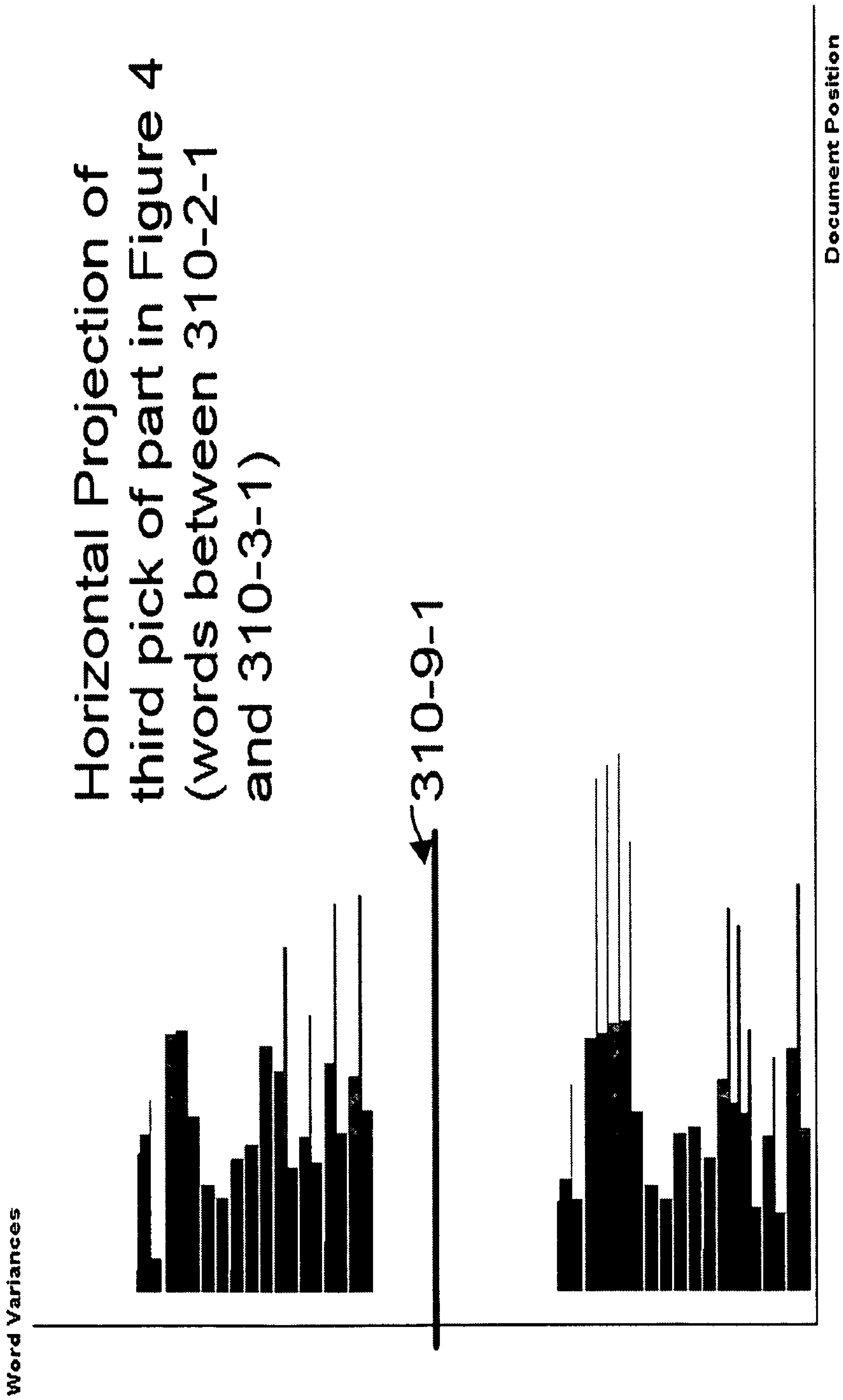

Horizontal Projection of third pick of part in Figure 4 (words between 310-2-1 and 310-3-1)
310-9-1
Word Variances
Document Position

FIG. 7

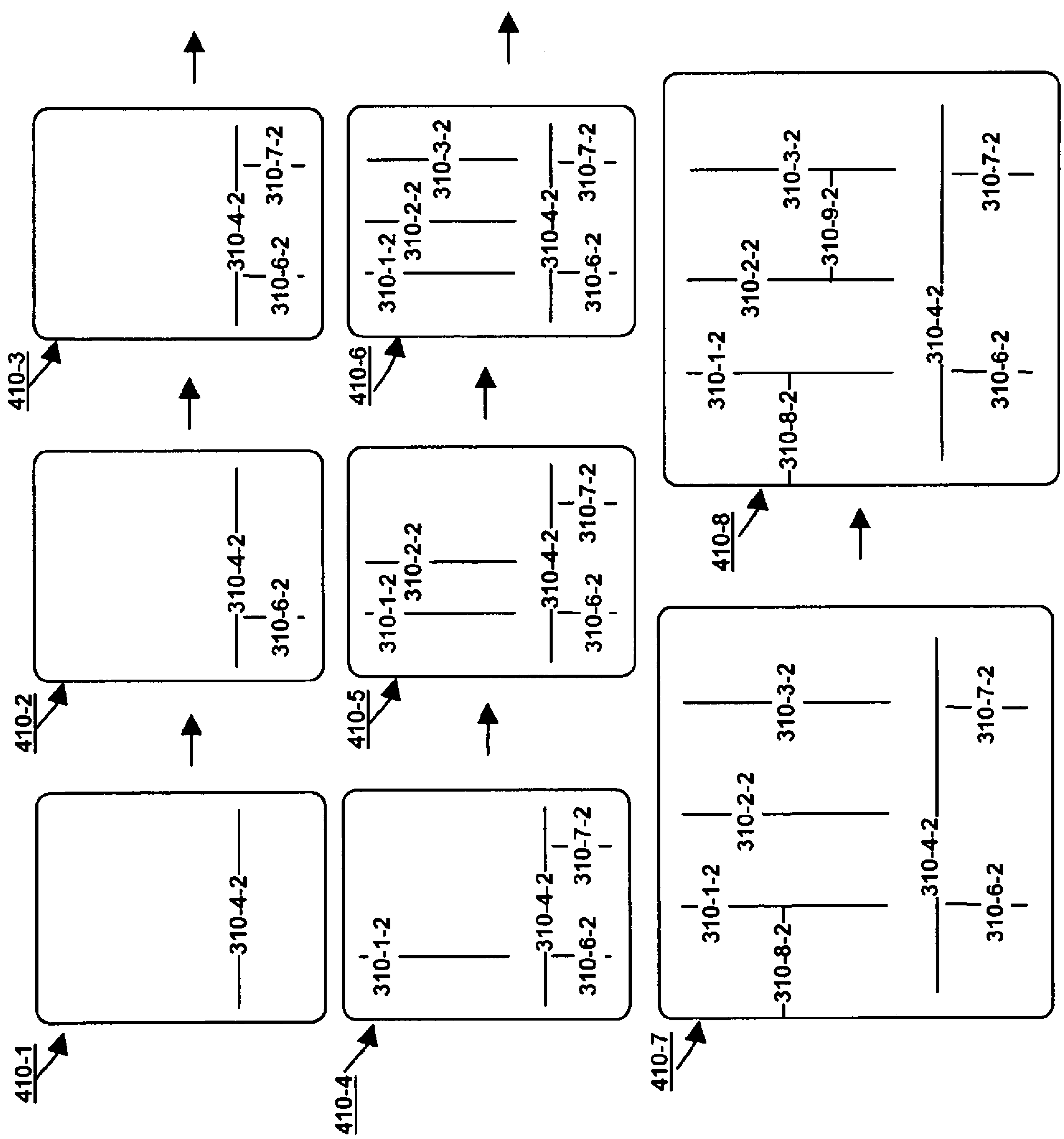

410-1
310-4-2
410-2
310-6-2
410-3
310-7-2
410-4
310-1-2
410-5
310-2-2
410-6
310-3-2
410-7
310-8-2
410-8
310-9-2

FIG. 8

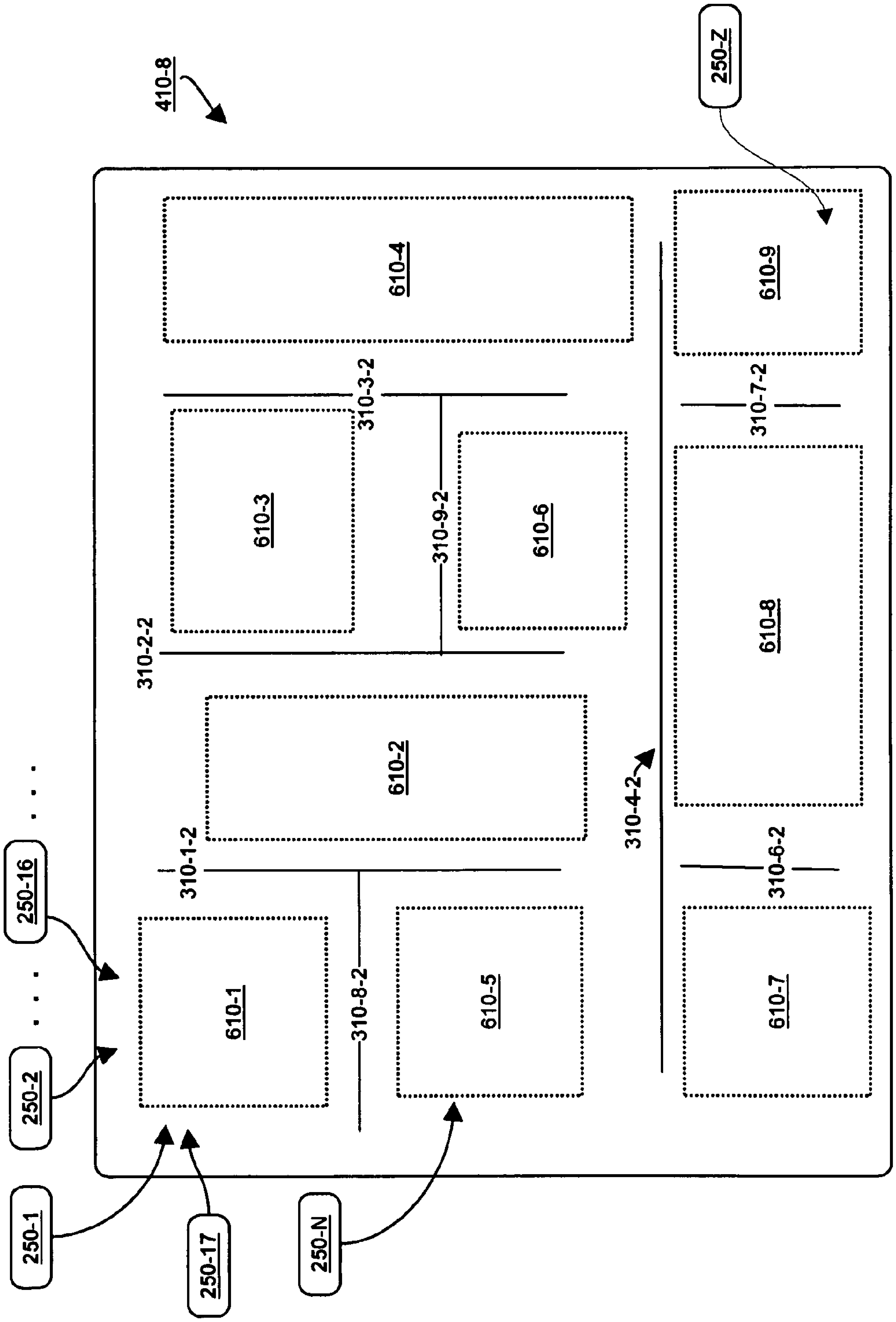
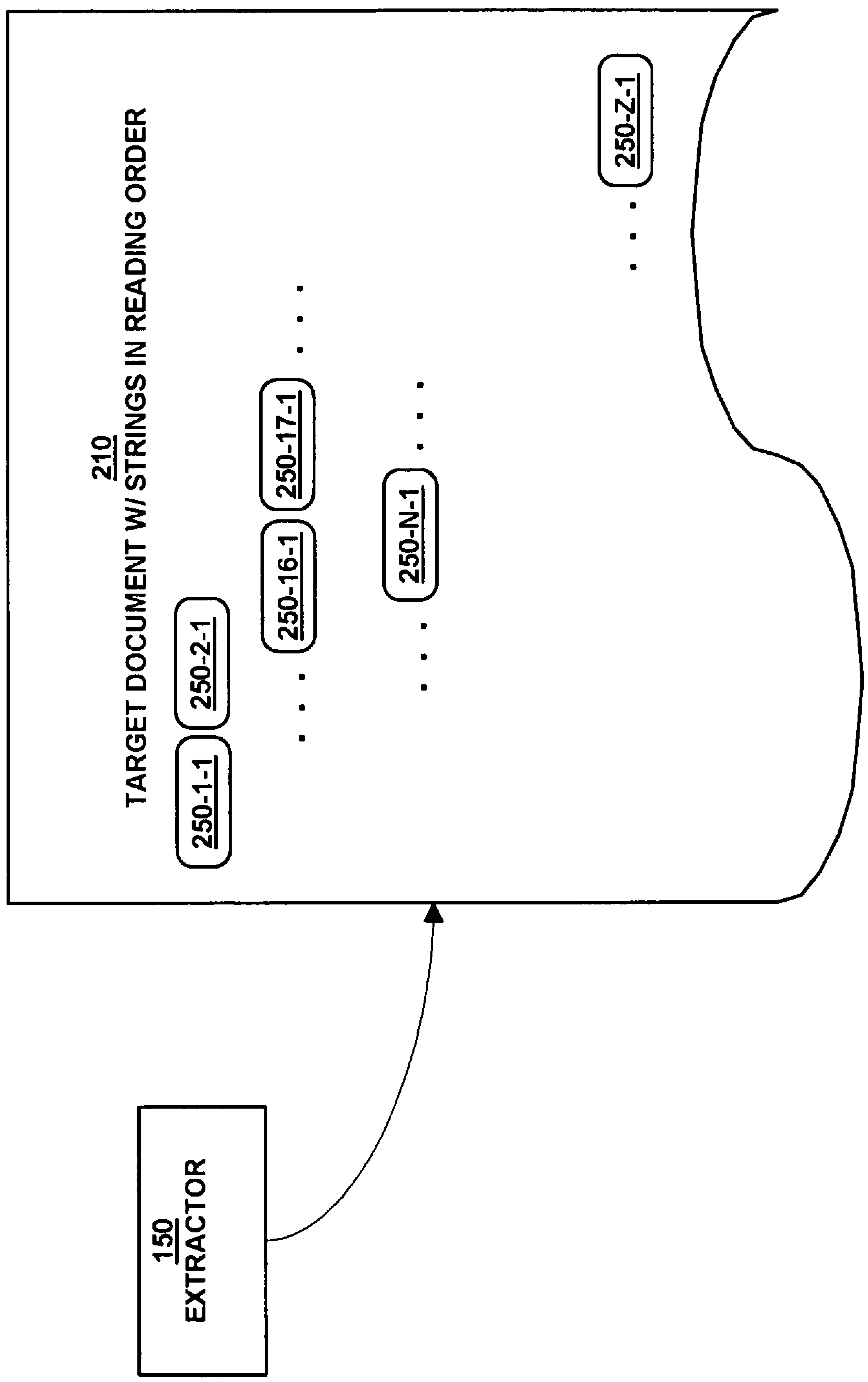
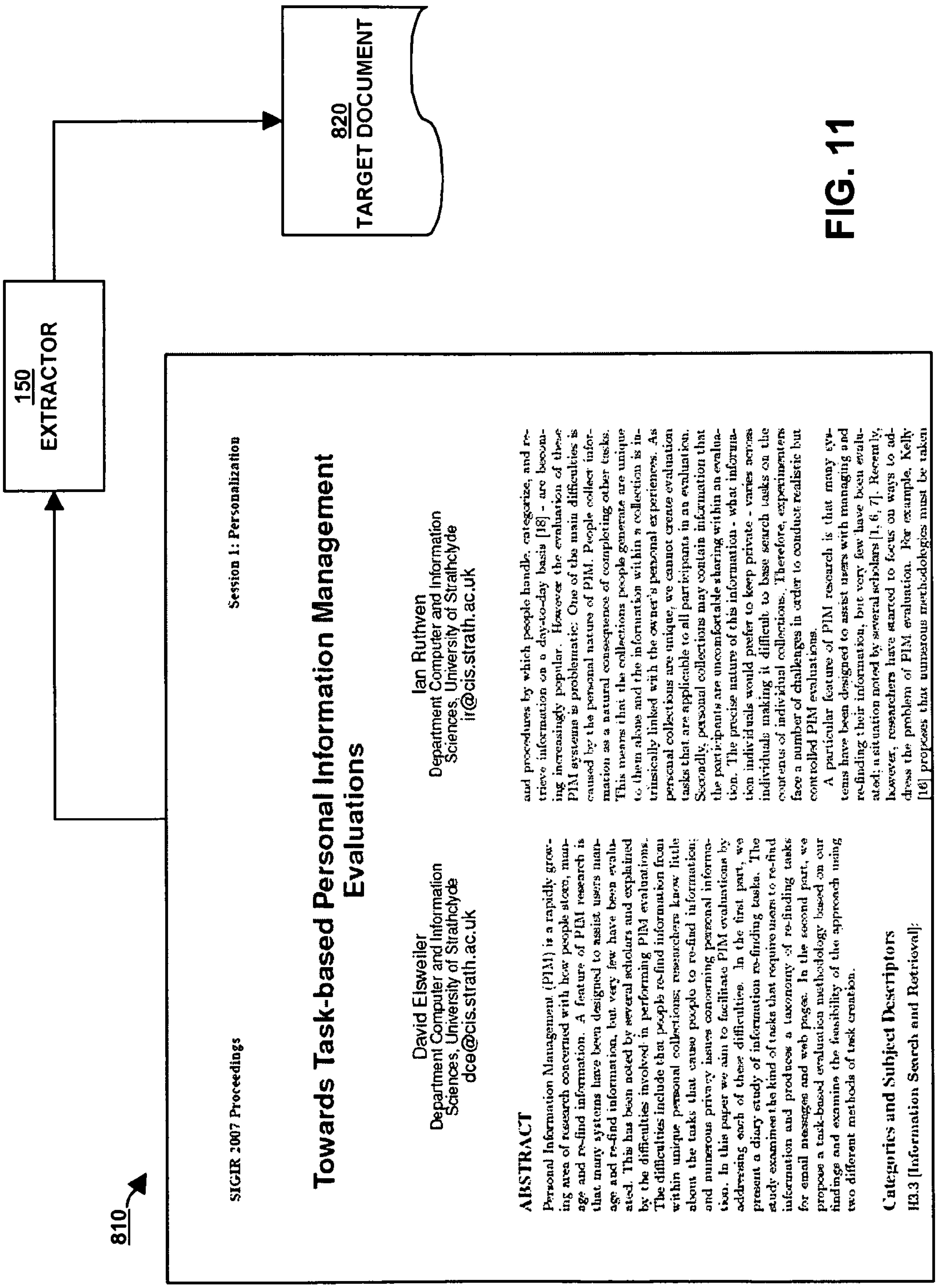

410-8
250-Z
610-4
610-9
310-3-2
310-7-2
610-3
310-9-2
610-6
610-8
310-2-2
610-2
310-4-2
250-16
310-1-2
310-6-2
610-1
310-8-2
610-5
610-7
250-2
250-1
250-17
250-N

FIG. 9



210
TARGET DOCUMENT W/ STRINGS IN READING ORDER
250-1-1
250-2-1
250-16-1
250-17-1
250-N-1
250-Z-1
150
EXTRACTOR

FIG. 10


150
EXTRACTOR
820
TARGET DOCUMENT
810
SIGIR 2007 Proceedings
Session 1: Personalization
Towards Task-based Personal Information Management Evaluations
David Elsweiler
Department Computer and Information Sciences, University of Strathclyde
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Ian Ruthven
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ABSTRACT
Categories and Subject Descriptors

FIG. 11

820

Session 1: Personalization

Towards Task-based Personal Information Management Evaluations

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ABSTRACT
Personal Information Management (PIM) is a rapidly growing area of research concerned with how people store, manage and re-find information. A feature of PIM research is that many systems have been designed to assist users manage and re-find information, but very few have been evaluated. This has been noted by several scholars and explained by the difficulties involved in performing PIM evaluations. The difficulties include that people re-find information from within unique personal collections; researchers know little about the tasks that cause people to re-find information; and numerous privacy issues concerning personal information. In this paper we aim to facilitate PIM evaluations by addressing each of these difficulties In the first part, we present a diary study of information re-finding tasks. The study examines the kind of tasks that require users to re-find information and produces a taxonomy of re-finding tasks for email messages and web pages. In the second part, we propose a task-based evaluation methodology based on our findings and examine the feasibility of the approach using two different methods of task creation.

Categories and Subject Descriptors
H3.3 [Information Search and Retrieval]:

General Terms
Measurement,Management,Experimentation,Human Factors

Keywords Personal Information Management, User Evaluation

1. INTRODUCTION
Personal InformationManagement (PIM) is a rapidly growing area of research concerned with how people store, manage and re-find information. PIM systems - the methods

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FIG. 12

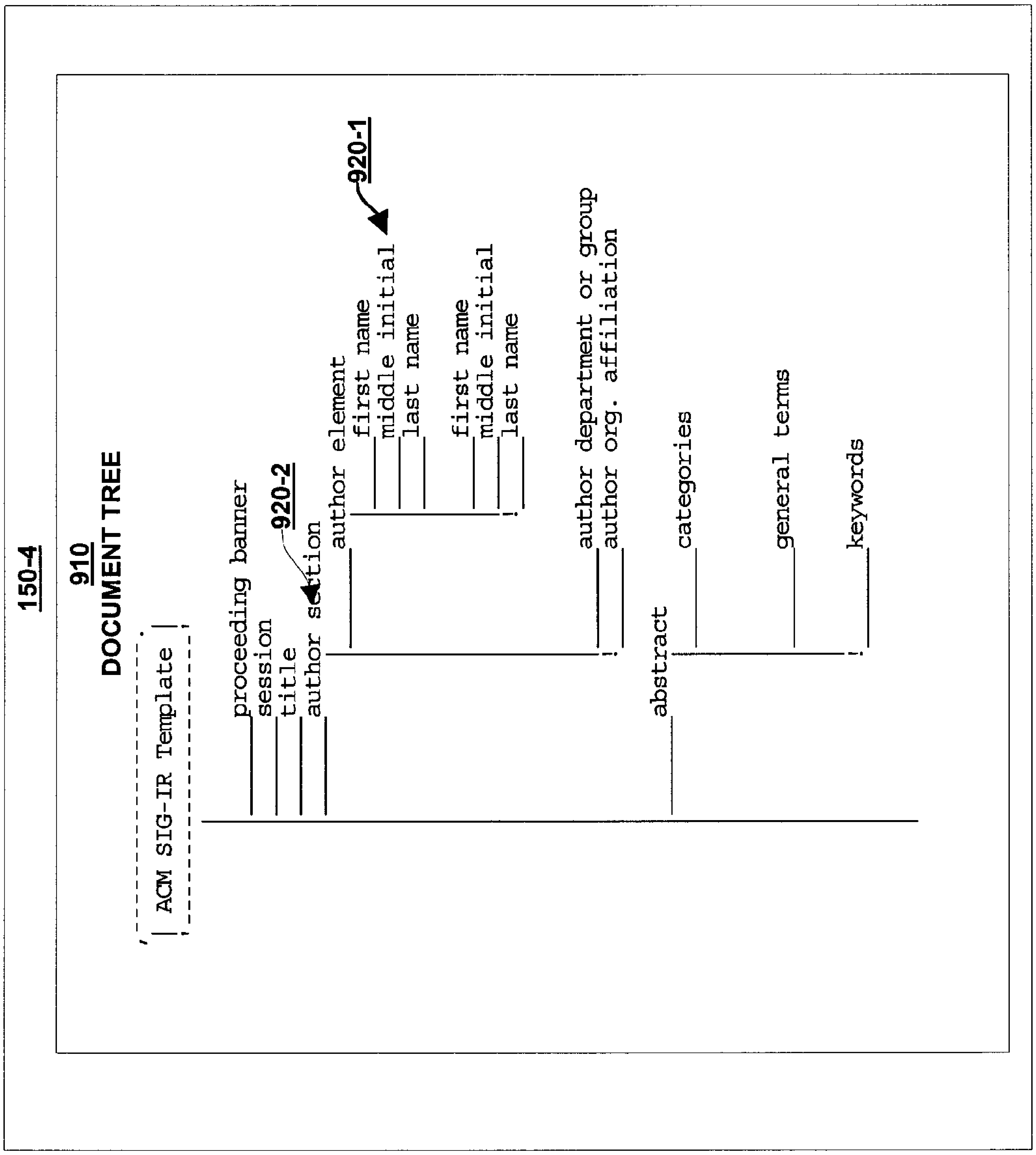
150-4
910
DOCUMENT TREE
ACM SIG-IR Template
proceeding banner
session
title
author section
920-2
author element
first name
middle initial
last name
first name
middle initial
last name
920-1
author department or group
author org. affiliation
abstract
categories
general terms
keywords

FIG. 13

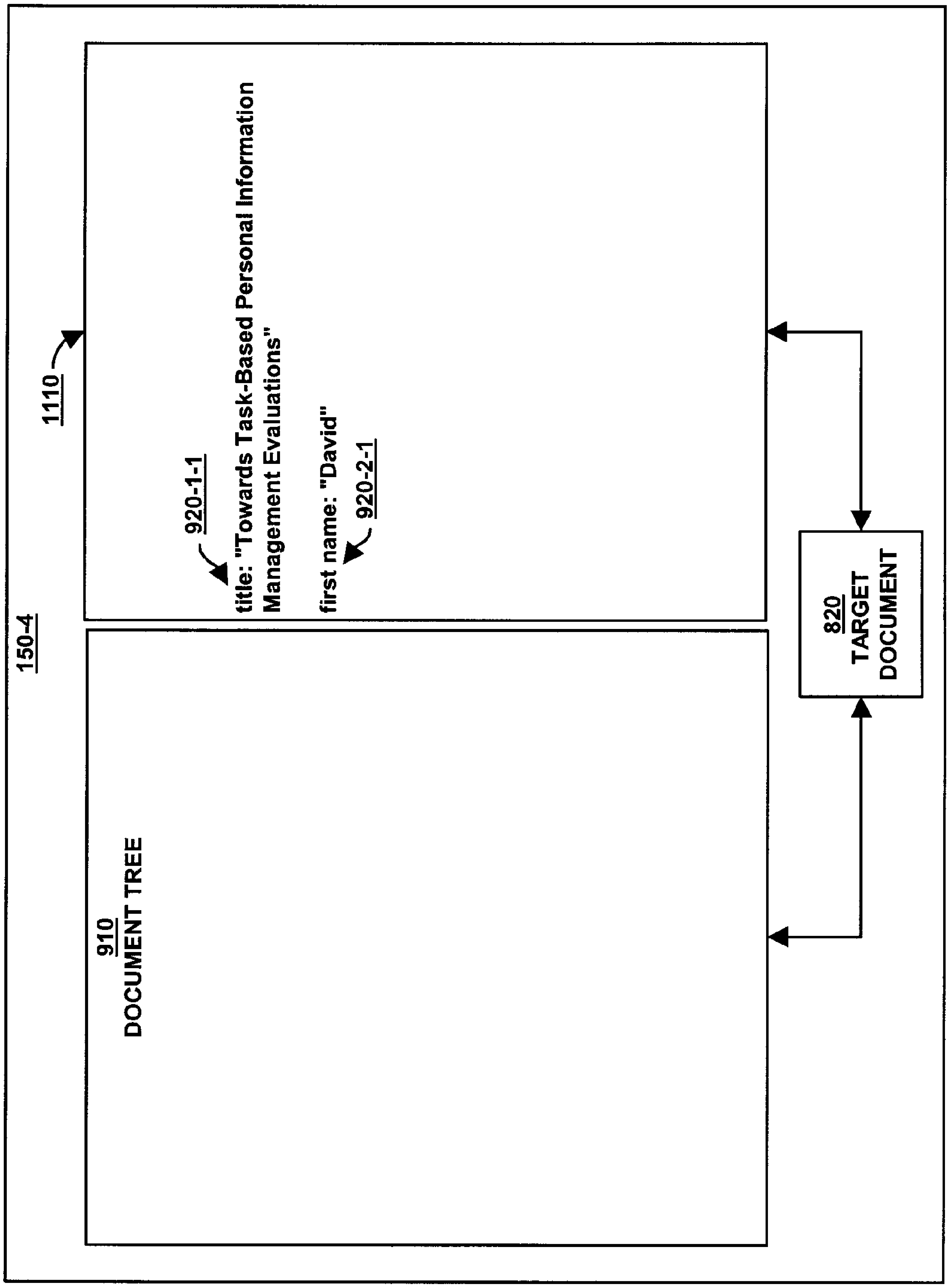
150-4
1110
920-1-1
title: "Towards Task-Based Personal Information Management Evaluations"
first name: "David"
920-2-1
910
DOCUMENT TREE
820
TARGET DOCUMENT

FIG. 14

150-4

1210


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FIG. 15

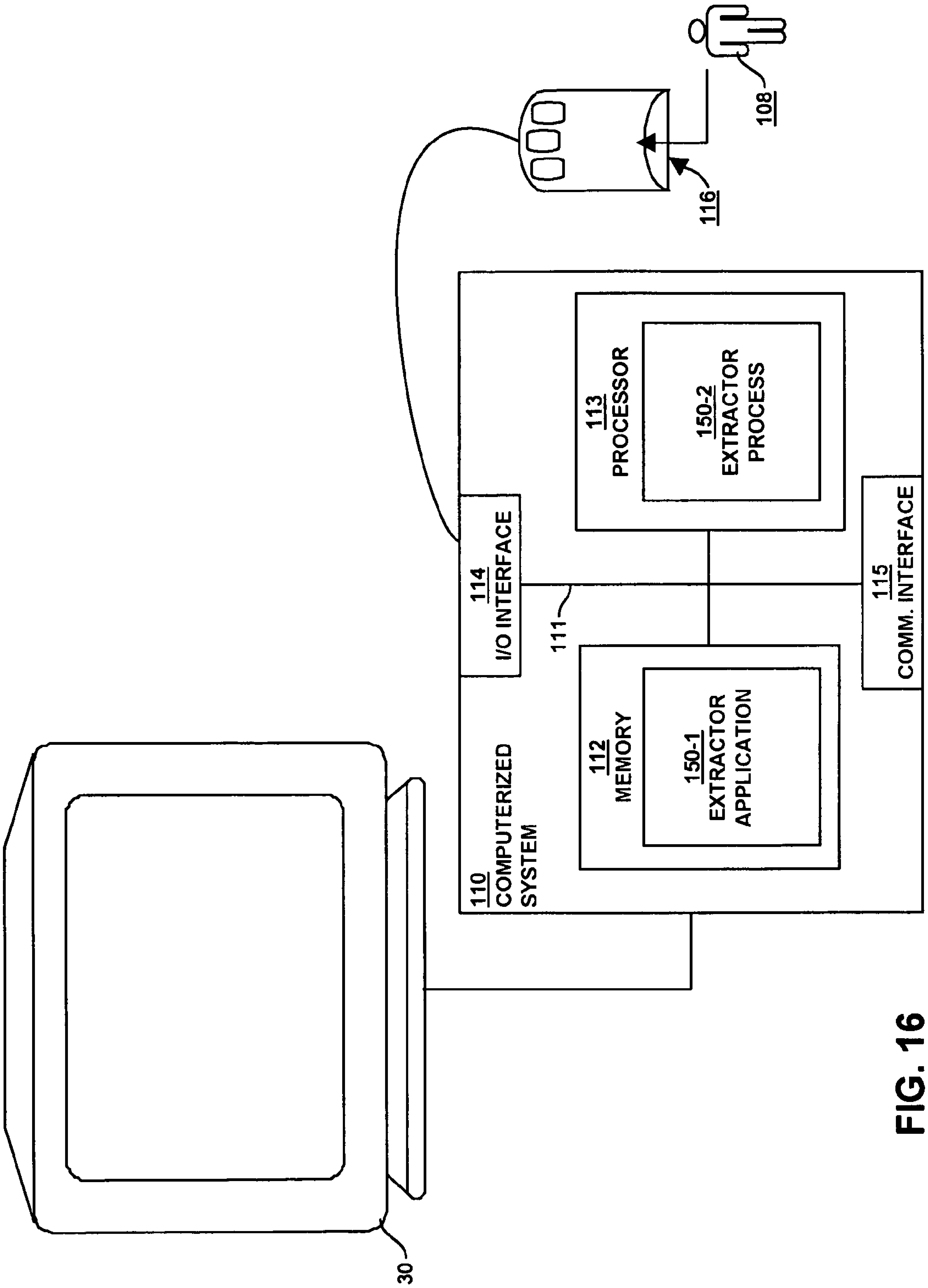

108
116
110
COMPUTERIZED
SYSTEM
112
MEMORY
150-1
EXTRACTOR
APPLICATION
113
PROCESSOR
150-2
EXTRACTOR
PROCESS
114
I/O INTERFACE
111
115
COMM. INTERFACE
130

FIG. 16

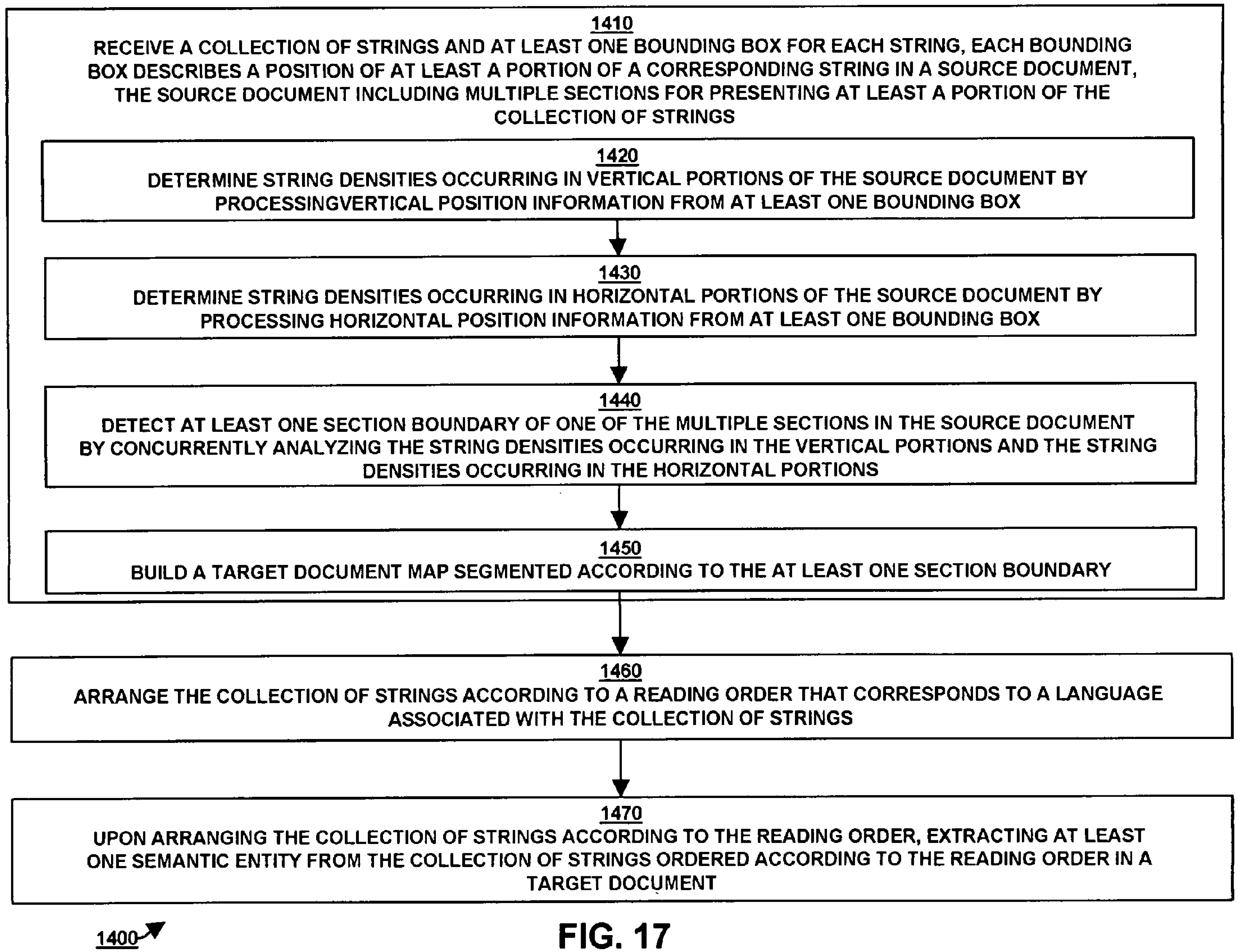
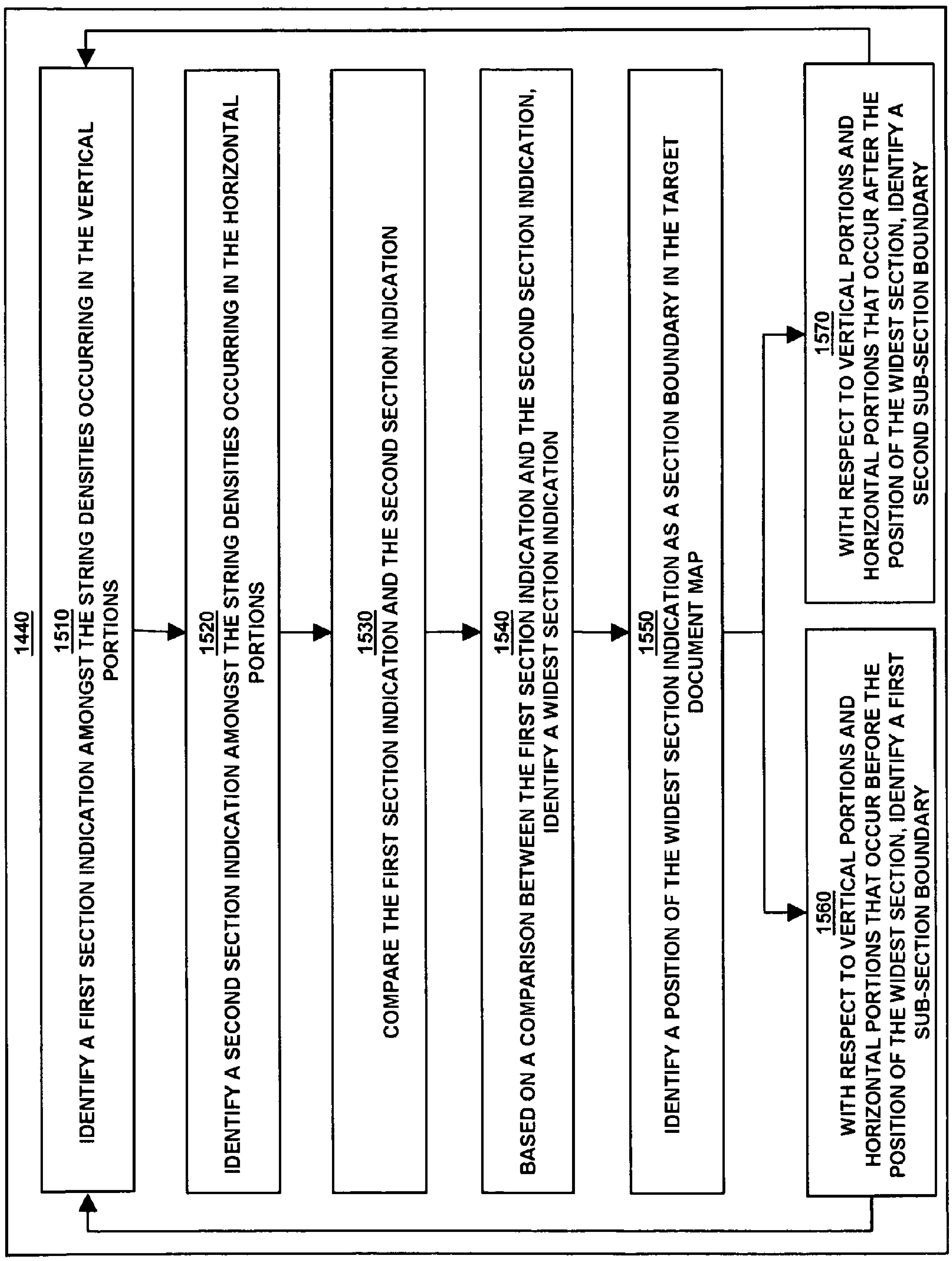

1410
RECEIVE A COLLECTION OF STRINGS AND AT LEAST ONE BOUNDING BOX FOR EACH STRING, EACH BOUNDING BOX DESCRIBES A POSITION OF AT LEAST A PORTION OF A CORRESPONDING STRING IN A SOURCE DOCUMENT, THE SOURCE DOCUMENT INCLUDING MULTIPLE SECTIONS FOR PRESENTING AT LEAST A PORTION OF THE COLLECTION OF STRINGS
1420
DETERMINE STRING DENSITIES OCCURRING IN VERTICAL PORTIONS OF THE SOURCE DOCUMENT BY PROCESSINGVERTICAL POSITION INFORMATION FROM AT LEAST ONE BOUNDING BOX
1430
DETERMINE STRING DENSITIES OCCURRING IN HORIZONTAL PORTIONS OF THE SOURCE DOCUMENT BY PROCESSING HORIZONTAL POSITION INFORMATION FROM AT LEAST ONE BOUNDING BOX
1440
DETECT AT LEAST ONE SECTION BOUNDARY OF ONE OF THE MULTIPLE SECTIONS IN THE SOURCE DOCUMENT BY CONCURRENTLY ANALYZING THE STRING DENSITIES OCCURRING IN THE VERTICAL PORTIONS AND THE STRING DENSITIES OCCURRING IN THE HORIZONTAL PORTIONS
1450
BUILD A TARGET DOCUMENT MAP SEGMENTED ACCORDING TO THE AT LEAST ONE SECTION BOUNDARY
1460
ARRANGE THE COLLECTION OF STRINGS ACCORDING TO A READING ORDER THAT CORRESPONDS TO A LANGUAGE ASSOCIATED WITH THE COLLECTION OF STRINGS
1470
UPON ARRANGING THE COLLECTION OF STRINGS ACCORDING TO THE READING ORDER, EXTRACTING AT LEAST ONE SEMANTIC ENTITY FROM THE COLLECTION OF STRINGS ORDERED ACCORDING TO THE READING ORDER IN A TARGET DOCUMENT
1400

FIG. 17


1440
1510
IDENTIFY A FIRST SECTION INDICATION AMONGST THE STRING DENSITIES OCCURRING IN THE VERTICAL PORTIONS
1520
IDENTIFY A SECOND SECTION INDICATION AMONGST THE STRING DENSITIES OCCURRING IN THE HORIZONTAL PORTIONS
1530
COMPARE THE FIRST SECTION INDICATION AND THE SECOND SECTION INDICATION
1540
BASED ON A COMPARISON BETWEEN THE FIRST SECTION INDICATION AND THE SECOND SECTION INDICATION, IDENTIFY A WIDEST SECTION INDICATION
1550
IDENTIFY A POSITION OF THE WIDEST SECTION INDICATION AS A SECTION BOUNDARY IN THE TARGET DOCUMENT MAP
1560
WITH RESPECT TO VERTICAL PORTIONS AND HORIZONTAL PORTIONS THAT OCCUR BEFORE THE POSITION OF THE WIDEST SECTION, IDENTIFY A FIRST SUB-SECTION BOUNDARY
1570
WITH RESPECT TO VERTICAL PORTIONS AND HORIZONTAL PORTIONS THAT OCCUR AFTER THE POSITION OF THE WIDEST SECTION, IDENTIFY A SECOND SUB-SECTION BOUNDARY

1500

FIG. 18

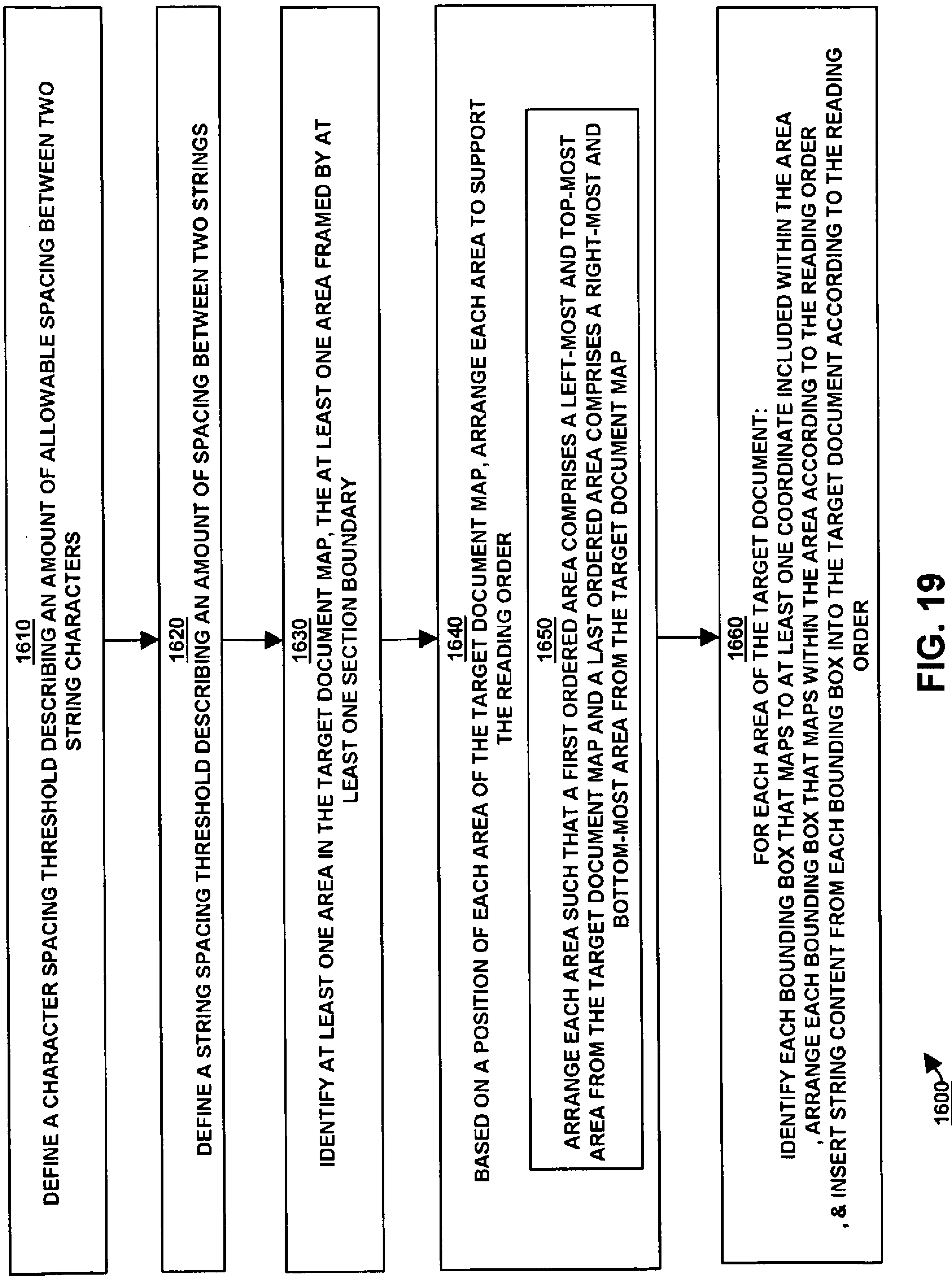
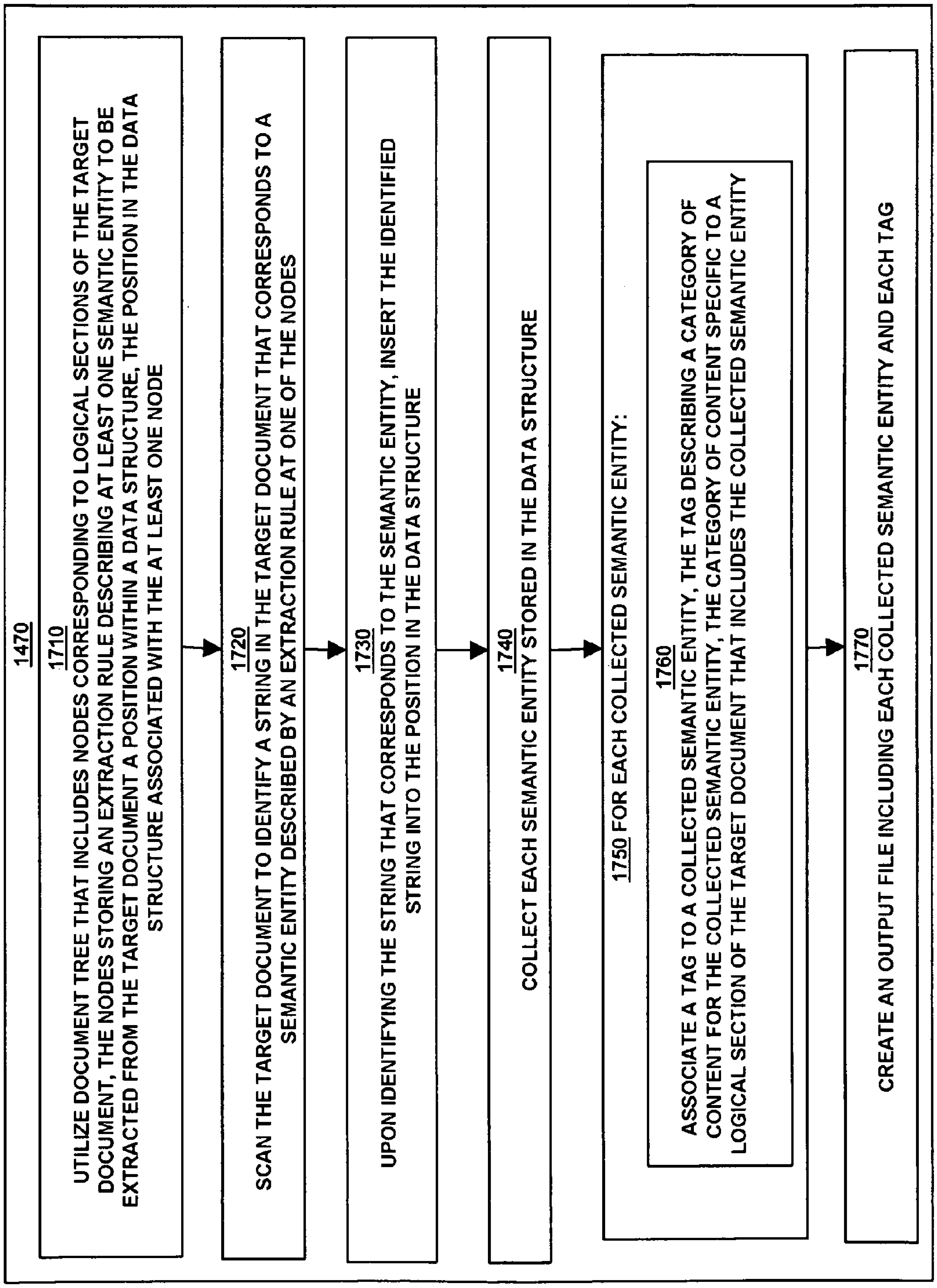

1610
DEFINE A CHARACTER SPACING THRESHOLD DESCRIBING AN AMOUNT OF ALLOWABLE SPACING BETWEEN TWO STRING CHARACTERS
1620
DEFINE A STRING SPACING THRESHOLD DESCRIBING AN AMOUNT OF SPACING BETWEEN TWO STRINGS
1630
IDENTIFY AT LEAST ONE AREA IN THE TARGET DOCUMENT MAP, THE AT LEAST ONE AREA FRAMED BY AT LEAST ONE SECTION BOUNDARY
1640
BASED ON A POSITION OF EACH AREA OF THE TARGET DOCUMENT MAP, ARRANGE EACH AREA TO SUPPORT THE READING ORDER
1650
ARRANGE EACH AREA SUCH THAT A FIRST ORDERED AREA COMPRISES A LEFT-MOST AND TOP-MOST AREA FROM THE TARGET DOCUMENT MAP AND A LAST ORDERED AREA COMPRISES A RIGHT-MOST AND BOTTOM-MOST AREA FROM THE TARGET DOCUMENT MAP
1660
FOR EACH AREA OF THE TARGET DOCUMENT:
IDENTIFY EACH BOUNDING BOX THAT MAPS TO AT LEAST ONE COORDINATE INCLUDED WITHIN THE AREA
, ARRANGE EACH BOUNDING BOX THAT MAPS WITHIN THE AREA ACCORDING TO THE READING ORDER
, & INSERT STRING CONTENT FROM EACH BOUNDING BOX INTO THE TARGET DOCUMENT ACCORDING TO THE READING ORDER
1600

FIG. 19


1470
1710
UTILIZE DOCUMENT TREE THAT INCLUDES NODES CORRESPONDING TO LOGICAL SECTIONS OF THE TARGET DOCUMENT, THE NODES STORING AN EXTRACTION RULE DESCRIBING AT LEAST ONE SEMANTIC ENTITY TO BE EXTRACTED FROM THE TARGET DOCUMENT A POSITION WITHIN A DATA STRUCTURE, THE POSITION IN THE DATA STRUCTURE ASSOCIATED WITH THE AT LEAST ONE NODE
1720
SCAN THE TARGET DOCUMENT TO IDENTIFY A STRING IN THE TARGET DOCUMENT THAT CORRESPONDS TO A SEMANTIC ENTITY DESCRIBED BY AN EXTRACTION RULE AT ONE OF THE NODES
1730
UPON IDENTIFYING THE STRING THAT CORRESPONDS TO THE SEMANTIC ENTITY, INSERT THE IDENTIFIED STRING INTO THE POSITION IN THE DATA STRUCTURE
1740
COLLECT EACH SEMANTIC ENTITY STORED IN THE DATA STRUCTURE
1750 FOR EACH COLLECTED SEMANTIC ENTITY:
1760
ASSOCIATE A TAG TO A COLLECTED SEMANTIC ENTITY, THE TAG DESCRIBING A CATEGORY OF CONTENT FOR THE COLLECTED SEMANTIC ENTITY, THE CATEGORY OF CONTENT SPECIFIC TO A LOGICAL SECTION OF THE TARGET DOCUMENT THAT INCLUDES THE COLLECTED SEMANTIC ENTITY
1770
CREATE AN OUTPUT FILE INCLUDING EACH COLLECTED SEMANTIC ENTITY AND EACH TAG

1700

FIG. 20

EXTRACTING READING ORDER TEXT AND SEMANTIC ENTITIES

BACKGROUND

Conventional algorithms exist that determine a given document's physical page layout, such as a given document's organization of distinct columns and sections of reading text. One conventional technique extracts a given document's page layout structure by analyzing the spatial configuration of word positions in the given document and graphically representing those word positions. An image of the document can be segmented by applying a recursive procedure to the graphically represented word positions. The original document's segmentation is indicated wherever a prominent gap exists in the graphically represented word positions. The recursive procedure iterates until no prominent gaps can be detected in the graphically represented word positions. Some attempts have been made to leverage information from such a recursive procedure to assist in reading-order text extraction.

Reading-order text extraction is the process by which text from a given document can be placed in the order the text is meant to be read (e.g. left-to-right, top-to-bottom) in lines of text that span across an entire document—as opposed to lines that only span across a column or section of text.

For example, if a given document, such as a newspaper, has two columns of text, then a human reader intuitively knows to read all the text in the left-most column before reading the text in the right-most column. The human reader thereby begins reading text in the right-most column only after reaching the last word in the bottom line of text in the left-most column. By applying reading-order text extraction to the given document, all the text from the right-most column will be placed across a page, left-to-right, and then text from the left-most column is placed on the page after text from the right-most column and no columns or sections will appear on the page.

The ability to accurately extract text in reading-order from segmented documents provides many advantages. Since many documents have different physical layouts, reading-order extraction allows for collecting and organizing text from all documents in a uniform layout. By maintaining the reading-order of the documents while discarding each document's various column and/or section breaks, search algorithms can better find keywords and/or semantic entities that appear in the extracted text.

Current conventional techniques suffer from a variety of deficiencies. Specifically, the recursive procedures used in current techniques fail to take into account character heights and widths that occur before and after the indications of segmentation from a given document. The failure of conventional techniques to take into account such character heights and widths is a critical deficiency as it leads to improperly characterizing line or paragraph breaks as identified segments or identified column breaks in a document.

When conventional techniques cast a paragraph break or line break that occurs within an actual column as the beginning of a new segment or another column, then there is a likelihood that text from the actual column will not be extracted in reading order since the conventional techniques will behave as though it is extracting text from two different columns with unrelated text.

Furthermore, the mechanism in current techniques for finding indications of segmentation from a given document, further fail to account for word starting frequencies, break alignment and/or relative straightness. Thus, conventional techniques often mischaracterize a given document's physical layout. Since conventional techniques risk finding incorrect segmentation of a document's physical layout, then the accuracy of proper reading-order text extraction will be suspect

SUMMARY

Techniques discussed herein significantly overcome the deficiencies of conventional applications such as those discussed above as well as additional techniques also known in the prior art. As will be discussed further, certain specific embodiments herein are directed to an Extractor.

The Extractor can receive a source document which includes groups of strings (e.g. words) organized within a number or columns and/or sections. The Extractor scans the source document to identify each string and creates bounding boxes for each string in the source document. The bounding box for each string describes the vertical and horizontal placement of the string within the source document. For example, a string's bounding box can provide X-Y coordinates that describe where a string (or a string portion) is located in the source document.

Based on bounding boxes that describe the positions of individual strings within a source document, the Extractor identifies a physical layout (e.g. section breaks, column breaks) of the source document. The Extractor builds a target document map to describe the placement of section and column breaks within the source document. For each area framed by section and column breaks in the target document map, the Extractor matches bounding boxes that describe string positions that fall within the position of the area. The Extractor then inserts the strings in a target document according to a reading order—absent the physical layout of the source document.

Upon creation of the target document, the Extractor scans the target document to identify any strings that correspond with predefined semantic entities. The Extractor uses a document tree to extract the semantic entities from the target document, tag the extracted semantic entities, and to store the extracted semantic entities in a data structure. The document tree includes nodes that correspond with logical sections (e.g. title, author section, abstract) of the target document. Each node has an extraction rule that describes a particular semantic entity that pairs with the node.

When the Extractor identifies the correct semantic entity for a particular node in the document tree, the semantic entity is stored in a position within a data structure that corresponds with the node. The Extractor tags the stored semantic entity. The tag describes a category of content (e.g. "doc_title,", "doc_author") that is related to the logical section of the target document from which the stored semantic entity was extracted. When all semantic entities have been extracted, stored and tagged, the Extractor creates an output file, such as an Extensible Markup Language (XML) file, that includes each semantic entity and its respective tag(s).

Other embodiments disclosed herein include any type of computerized device, workstation, handheld or laptop computer, or the like configured with software and/or circuitry (e.g., a processor) to process any or all of the method operations disclosed herein. In other words, a computerized device such as a computer or a data communications device or any type of processor that is programmed or configured to operate as explained herein is considered an embodiment disclosed herein.

Other embodiments disclosed herein include software programs to perform the steps and operations summarized above and disclosed in detail below. One such embodiment comprises a computer program product that has a computer-readable medium (e.g., tangible computer-readable medium) including computer program logic encoded thereon that, when performed in a computerized device having a coupling of a memory and a processor, programs the processor to perform the operations disclosed herein. Such arrangements are typically provided as software, code and/or other data (e.g., data structures) arranged or encoded on a computer readable medium such as an optical medium (e.g., CD-ROM), floppy or hard disk or other a medium such as firmware or microcode in one or more ROM or RAM or PROM chips or as an Application Specific Integrated Circuit (ASIC). The software or firmware or other such configurations can be installed onto a computerized device to cause the computerized device to perform the techniques explained as embodiments disclosed herein.

It is to be understood that the system disclosed herein may be embodied strictly as a software program, as software and hardware, or as hardware alone. The embodiments disclosed herein, may be employed in software and hardware such as those manufactured by Adobe Systems Incorporated of San Jose, Calif., U.S.A., herein after referred to as "Adobe" and "Adobe Systems."

Additionally, although each of the different features, techniques, configurations, etc. herein may be discussed in different places of this disclosure, it is intended that each of the concepts can be executed independently of each other or in combination with each other. Accordingly, the present invention can be embodied and viewed in many different ways.

Note also that this summary section herein does not specify every embodiment and/or incrementally novel aspect of the present disclosure or claimed invention. Instead, this summary only provides a preliminary discussion of different embodiments and corresponding points of novelty over conventional techniques. For additional details and/or possible perspectives (permutations) of the invention, the reader is directed to the Detailed Description section and corresponding figures of the present disclosure as further discussed below.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of embodiments of the methods and apparatus for a Extractor, as illustrated in the accompanying drawings and figures in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, with emphasis instead being placed upon illustrating the embodiments, principles and concepts of the methods and apparatus in accordance with the invention.

FIG. **1** is an example block diagram of an Extractor producing a target document and an output file based on a received source document and a collection of bounding boxes associated with strings in the source document according to embodiments herein.

FIG. **2** is an example block diagram of a source document having a physical layout segmented by multiple sections according to embodiments herein.

FIG. **3** is an example block diagram of a collection of bounding boxes describing positions of strings within a source document according to embodiments herein.

FIG. **4** is an example block diagram of section boundaries detected by an Extractor within string densities occurring in horizontal and vertical portions of a source document according to embodiments herein.

FIG. **5** is an example block diagram of sub-section boundaries detected by an Extractor within strings densities occurring in vertical portions of a source document according to embodiments herein.

FIG. **6** is an example block diagram of sub-section boundaries detected by an Extractor within strings densities occurring in horizontal portions of a source document according to embodiments herein.

FIG. **7** is an example block diagram of sub-section boundaries detected by an Extractor within strings densities occurring in horizontal portions of a source document according to embodiments herein.

FIG. **8** is an example block diagram of an Extractor recursively building a target document map based on valid section and sub-section boundaries detected among strings densities occurring in horizontal and vertical portions according to embodiments herein.

FIG. **9** is an example block diagram of an Extractor identifying areas framed within section boundaries according to embodiments herein.

FIG. **10** is an example block diagram of an Extractor providing a target document with strings from a source document arranged in a reading order according to embodiments herein.

FIG. **11** is an example block diagram of an Extractor creating a target document based on a source document according to embodiments herein.

FIG. **12** is an example block diagram of a target document created by an Extractor according to embodiments herein.

FIG. **13** is an example block diagram of a document tree with nodes that correspond to logical sections of a target document according to embodiments herein.

FIG. **14** is an example block diagram of semantic entities extracted from a target document and inserted into a data structure position that corresponds with anode of a document tree to embodiments herein.

FIG. **15** is an example block diagram of an output file of tagged semantic entities according to embodiments herein.

FIG. **16** is an example block diagram illustrating an architecture of a computer system that executes an Extractor application and/or an Extractor process according to embodiments herein.

FIG. **17** is a flowchart of an example of processing steps performed by the Extractor to extract semantic entities from a target document according to embodiments herein.

FIG. **18** is a flowchart of an example of processing steps performed by the Extractor to identify section indications and sub-section indications amongst string densities occurring in vertical and horizontal portions of a source document according to embodiments herein.

FIG. **19** is a flowchart of an example of processing steps performed by the Extractor to arrange areas within target document map according to a reading order according to embodiments herein.

FIG. **20** is a flowchart of an example of processing steps performed by the Extractor to create an output file with semantic entities and tags for each semantic entity according to embodiments herein.

DETAILED DESCRIPTION

FIG. **1** is an example block diagram of an Extractor **150** producing a target document **210** and an output file **220** based on a received source document **200** and a collection of bounding boxes **250** associated with strings in the source document **200** according to embodiments herein.

The Extractor **150** receives a collection of strings within a source document **200** and bounding boxes **250-1** . . . **250**-Z for each string. Each bounding box **250-1** . . . **250**-Z describes a position of at least a portion of a corresponding string in the source document **200**. The source document **200** includes multiple sections for presenting portions of the collection of strings in the source document **200**, such as column breaks and/or sub-section breaks within a column.

By processing vertical position information from the bounding boxes **250-1** . . . **250**-Z, the Extractor **150** determines string densities **320** that occur in vertical portions of the source document **200**. By processing horizontal position information from the bounding boxes **250-1** . . . **250**-Z, the Extractor **150** determines string densities **325** that occur in the horizontal portions of the source document **200**.

The Extractor **150** performs a recursive analysis **150-3** on the vertical and horizontal string densities **320**, **320** in order to detect the section boundaries in the source document **200**. As the Extractor **150** performs recursive analysis **150-3**, the Extractor **150** builds a target document map **410** that reflects the segmentation detected among the vertical and horizontal string densities **320**, **320**—where the segmentation is represented as indications of string absences within the string densities **320**, **320**.

Based on the position information provided by each bounding box **250-1** . . . **250**-Z, the Extractor **150** maps strings to areas in the target document map **410** that are framed by the section boundaries detected in the source document's **200** physical layout. When inserting the strings into a target document **210**, the Extractor **150** utilizes the areas in the target document map **410** to determine which strings share the same sentence—but the strings are inserted into the target document **210** according to a reading order and without the segmentation (i.e. column breaks, sub-section breaks) of the source document **200**.

Upon arranging the collection of strings according to the reading order in the target document **210**, the Extractor **150** utilizes a tagging module **150-4** to collect semantic entities **240** from the target document **210**. For each collected semantic entity **240**, the Extractor **150** tags the collected semantic entity **240** with a tag **230** that describes a category of content that corresponds to a logical section of the target document **210** from which the semantic entity was extracted. The Extractor **150** creates an output file **220**, such as an XML file, that includes each collected semantic entity **240** with a corresponding tag **230**.

It is understood that, for various embodiments of the Extractor, reading order of the text (or strings) indicates how a human would sequentially read text in order to properly understand each sentence of each paragraph or each section.

It is further understood that, for various embodiments of the Extractor, a semantic entity is string(s) built from a sequence of one or more text (i.e. text tokens) that can be classified into predefined categories such as the names of persons, living or inanimate objects, organizations, locations, products, expressions of times, quantities, monetary values, percentages and the like.

FIG. **2** is an example block diagram of a source document **200** having a physical layout segmented by multiple sections **310-1**, **310-2**, **310-3**, **310-4**, **310-5**, **310-6**, **310-7**, **310-8**, **310-9** according to embodiments herein. As illustrated in FIG. **1**, the source document organizes text (i.e. a collection of strings) amongst column and sub-section breaks. Specifically, the source document **200** contains three sections **310-1**, **310-2**, **310-3**, and two sub-sections **310-6**, **310-7** where there is very little text—thereby creating vertical column breaks. In addition, the source document **200** contains one section break **310-4** and two sub-section breaks **310-8**, **310-9** that create horizontal sections in the source document's **200** physical layout.

When reading text within a column or sub-section break **310-1** . . . **310-9**, a human knows to traverse all the text within a column or sub-section break **310-1** . . . **310-9** and not to include a reading of other text in another column or sub-section break **310-1** . . . **310-9**. Thus, the reading pattern used by a human is to read text on a "per-section" basis rather than reading across the source document **200** by traversing column or sub-section breaks **310-1** . . . **310-9**.

Turning now to FIG. **3**, FIG. **3** is an example block diagram of a collection of bounding boxes **250** describing positions of strings within a source document **200** according to embodiments herein. A bounding box can represent a position of a rectangular area encompassed by a string (or a string portion) in the source document. However, the Extractor is not limited to bounding boxes representing only rectangular areas and can be interpreted as a positional description of a string (or a string portion) in the source document.

As illustrated in FIG. **3**, the sixteenth bounding box **250-16** describes a position of a string that occurs just before a column break in the source document **200**. The seventeenth bounding box **250-17** describes the position of the next string in the sentence. However, the seventeenth bounding box **250-17** does not describe a position directly to the right of the sixteenth bounding box **250-16**, such as over the column break. Instead, the seventeenth bounding box **250-17** describes a position such that the corresponding string is the first string in a line of text directly below the line of text that includes the sixteenth bounding box **250-16**.

When arranging the sixteenth bounding box **250-16** and the seventeenth bounding box **250-17** according to a reading order in a target document **200**, the Extractor **150** aligns the bounding boxes **250-16**, **250-17** such that no column break (or section break) will force the seventeenth bounding box **250-17** to occur at a different line of text.

An additional bounding box **250**-N describes a position of a string at the beginning of a line of text and the last bounding box **250**-Z describes a position of the left-most, bottom-most string in the source document **200**. When the Extractor **150** arranges the collection of strings according to the reading order in the target document **210**, the string associated with the additional bounding box **250**-N will not necessarily appear as the first string in a line of text. Nonetheless, the string associated with the last bounding box **250**-Z will be the last string in the target document **210**.

FIG. **4** is an example block diagram of section boundaries **310-1-1**, **310-2-1**, **310-3-1**, **310-4-1** detected by an Extractor **150** within string densities **320**, **325** occurring in horizontal and vertical portions of a source document **200** according to embodiments herein. Also, FIGS. **5-7** are example block diagrams of sub-section boundaries **310-6-1**, **310-7-1**, **310-8-1**, **310-9-1** detected by the Extractor **150** within string densities **320**, **325** occurring in vertical or horizontal portions of the source document **200** according to embodiments herein. As the Extractor **150** performs a recursive analysis **150-3** on the string densities **320**, **325**, the Extractor **150** builds a target document map **410**.

FIG. **8** is an example block diagram of an Extractor **150** recursively building a target document map **410** based on valid section **310-1-1**, **310-2-1**, **310-3-1**, **310-4-1** and sub-section **310-6-1**, **310-7-1**, **310-8-1**, **310-9-1** boundaries detected among strings densities **320**, **325**. Aspects of the recursive analysis **150-3** performed by the Extractor **150** illustrated in FIGS. **4-7** will be discussed in conjunction with a discussion of aspects illustrated in FIG. **8**.

Upon receiving the collection of strings in the source document **200** and receiving the bounding boxes **250**, the Extractor **150** processes vertical position information and horizontal position information from the bounding boxes **250-1** . . . **250**-Z. The Extractor **150** thereby determines string densities **320** that occur in vertical portions of the source document **200** and determines string densities **325** that occur in horizontal portions of the source document **200**. In order to build a target document map **410** segmented according to the physical layout of the source document **200**, the Extractor **150** detects and validates indications of string absences within the string densities **320**, **325** as it recursively analyzes both the vertical and horizontal string densities **320**, **325**.

During an initial recursive pass over the string densities **320**, **325**, the Extractor **150** identifies a section indication **310-1-1** amongst the vertical string densities **320** by locating a continuously straight span. It is understood that a continuously straight span among the vertical string densities **320** is wider than a character width associated with (i) a string density positioned before the span and (ii) a string density positioned after the span.

Further, the Extractor **150** defines a threshold that describes an allowable amount of string density to be present in the continuously straight span. Thus, the continuously straight span need not represent a complete absence of text in order to be considered a section indication.

If the continuously straight span is wider than such character widths, then the Extractor **150** knows that the section indication **310-1-1** is a candidate section boundary for the target document map **410**. If the continuously straight span is not wider than such character widths, then the section indication **310-1-1** is an invalid span and will not be included in the target document map **410**. It is noted that conventional techniques fail to disclose a recursive analysis that includes validating spans with respect to character widths.

Still during the initial recursive pass over the string densities **320**, **325**, the Extractor **150** identifies a section indication **310-4-1** amongst the horizontal string densities **325** by locating another continuously straight span. It is understood that this continuously straight span among the horizontal string densities **325** must have a height that is greater than a character height associated with (i) a string density positioned before the span and (ii) a string density positioned after the span.

Further, the Extractor **150** defines another threshold that describes an allowable amount of string density to be present in this continuously straight span. Thus, the continuously straight span need not represent a complete absence of text in order to be considered a section indication.

If the continuously straight span is higher than such character heights, then the Extractor **150** knows that the section indication **310-4-1** is a candidate section boundary for the target document map **410**. If the continuously straight span is does not exceed the character heights, then the section indication **310-4-1** is an invalid span and will not be included in the target document map **410**. Again, it is noted that conventional techniques fail to disclose a recursive analysis that includes validating spans with respect to character heights.

When both section indications **310-1-1**, **310-4-1** are determined to be valid spans, the Extractor **150** compares both section indications **310-1-1**, **310-4-1** to identify which of the two section indications **310-1-1**, **310-4-1** is the widest. The Extractor **150** determines that the section indication **310-4-1** detected in the horizontal string densities **325** is the widest. Thus, the position of the "widest" section indication **310-4-1** is identified and the Extractor **150** creates a section boundary **310-4-2**, based on the position of the "widest" section indication **310-4-1**, in a version of the target document map **410-1** (see FIG. **8**).

In FIG. **5**, the Extractor **150** continues the recursive analysis **150-3** with respect to string densities that occur before the "widest" section indication **310-4-1**. The Extractor **150** determines that no "valid" spans exist in horizontal string densities **325** before the "widest" section indication **310-4-1**. However, sub-section indications **310-6-1**, **310-7-1** occur in vertical string densities **320** occurring before the "widest" section indication **310-4-1**.

Upon determining that both sub-section indications **310-6-1**, **310-7-1** are valid spans, and therefore candidate section boundaries, the Extractor **150** identifies the position of the right-most sub-section indication **310-6-1** and creates a section boundary **310-6-2**, in the target document map **410-2** based on the position of the right-most sub-section indication **310-6-1**. Next, the Extractor **150** identifies the position of the sub-section indication **310-7-1** and a section boundary **310-7-2**, based on the position of the sub-section indication **310-7-1**, is created in an updated version of the target document map **410-3** (see FIG. **8**).

While one branch of the recursive analysis detects sub-section indications **310-6-1**, **310-7-1**, the Extractor **150** concurrently analyzes string densities that occur after the "widest" section indication **310-4-1** that was detected during the first recursive pass as well.

As illustrated in FIG. **4**, the Extractor **150** again detects a right-most section indication **310-1-1** that occurs after the "widest" section indication **310-4-1** in the vertical string densities **320**. Upon validating the section indication **310-1-1** as a candidate section boundary, the Extractor **150** identifies the position of the section indication **310-1-1** and a section boundary **310-1-2**, based on the position of the section indication **310-1-1**, is created in an updated version of the target document map **410-4** (see FIG. **8**).

The recursive analysis **150-3** can again split into another sequence of iterations in order to look for section indications that occur before and after the section indication **310-1-1** as well. With regard to string densities that occur after the section indication **310-1-1**, the widest, valid spans will be section indications **310-2-1**, **310-3-1** that are detected during two recursive passes, respectively. Upon validating the section indications **310-2-1**, **310-3-1** as candidate section boundaries, the Extractor **150** identifies the positions of the section indications **310-2-1**, **310-3-1** and section boundaries **310-2-2**, **310-3-2** based on the positions of the section indications **310-2-1**, **310-3-1** are created in updated respective versions of the target document map **410-5**, **410-6** (see FIG. **8**).

As shown in FIG. **6**, the recursive analysis **150-3** continues as discussed above to further create another sub-section boundary **310-8-2** for updated target document map versions **410-7** that is based on a position of the detected and validated sub-section indication **310-8-1**.

As shown in FIG. **7**, the recursive analysis **150-3** continues as discussed above to further create another sub-section boundary **310-9-2** for updated target document map versions **410-8** that is based on a position of a detected and validated sub-section indication **310-9-1**.

It is understood that each version **410-1** . . . **410-8** of the target map can be generated recursively and not in a completely sequential fashion. Thus, for example, after creating the first version **410-1**, the Extractor **150** can concurrently perform the analysis required to create versions **410-2**, **410-3** while it performs the analysis required to create version **410-4**, **410-5**, **410-6**.

Turning now to FIG. **9**, FIG. **9** is an example block diagram of an Extractor **150** identifying areas **610-1**, **610-2**, **610-3**, **610-4**, **610-5**, **610-6**, **610-7**, **610-8**, **610-9** framed within section boundaries **310-1-2** . . . **310-8-2** according to embodiments herein.

The Extractor **150** identifies areas **610-1** . . . **610-9** in the target document map **410-8**. Each of the areas **610-1** . . . **610-9** are framed by the section boundaries **310-1-2** . . . **310-8-2** which reflect the segmentation of the source document **200**. Based on the position of each area **610-1** . . . **610-9** within the target document map **410-8**, the Extractor **150** arranges each area **610-1** . . . **610-9** to support the reading order such that a first ordered area **610-1** is the left-most-and-top-most area **610-1** and the last ordered area **610-9** is the right-most-and-bottom-most area **610-9**.

For each area **610-1** . . . **610-9** of the target document **410-8**, the Extractor **150** identifies each bounding box that describes a string position that maps to a coordinate included within the area. For example, bounding boxes **250-1**, **250-2** . . . **250-16**, **250-17** map to the first-ordered area **610-1**, the additional bounding box **250**-N maps to the fifth ordered area **610-5** and the final bounding box **250**-Z maps to the last ordered area **610-9**. It is understood that other multiple bounding boxes can map to the other ordered areas **610-2**, **610-3**, **610-4**, **610-6**, **610-7**, **610-8** as well.

For each bounding box **250** that maps to the an ordered area **610**, the Extractor **150** arranges the particular mapped bounding boxes **250** according to the reading order. The Extractor **150** defines a character spacing threshold that describes an amount of allowable spacing between two string characters and defines a string spacing threshold that describes an amount of spacing between two strings.

When the Extractor **150** identifies a particular bounding box **250** the maps to a particular area **610** in the target document map **410-8**, the Extractor **150** identifies a previous bounding box with respect to a position of the particular bounding box. If a spacing between the particular bounding box and the previous bounding box is within the character spacing threshold, the Extractor **150** combines the bounding boxes to form a complete string.

However, if the spacing between the particular bounding box and the previous bounding box is at least equal to the string spacing threshold, the Extractor **150** includes a space between the particular bounding box and the previous bounding box such that the bounding boxes reflect two separate strings in the target document **210**.

Regarding FIG. **10**, FIG. **10** is an example block diagram of an Extractor **150** providing a target document **210** with strings from a source document **200** arranged in a reading order according to embodiments herein.

The Extractor **150** sequentially inserts string content from each bounding box into the target document according to the reading order. For example, the bounding boxes that map to the first ordered area **610-1** will be sequentially inserted into the target document **210** such that the strings associated with bounding boxes will traverse across the target document **210**, left-to-right, without any column or section breaks.

For example, although a column break **310-1** in the source document **200** forces the strings **250-16-1**, **250-17-1** associated the sixteenth and seventeenth bounding boxes **250-16**, **250-17** to appear on different lines of text, the Extractor **150** inserts the strings **250-16-1**, **250-17-1** in sequence in the same line of text in the target document **210**.

Similarly, the Extractor **150** inserts the strings content **250-N-1** associated with additional bounding box **250**-N in a line of text that occurs after the strings **250-16-1**, **250-17-1** associated the sixteenth and seventeenth bounding boxes. However, where the additional bounding box **250**-N described a position of string starting at a line within a column in the source document **200**, the string content **250-N-1** associated with additional bounding box **250**-N appears within a line of text in a sequence of strings. Finally, since the final bounding box **250**-Z reflects the last position within the last ordered area **610-9**, string content **250**-Z-**1** associated with additional bounding box **250**-Z is the last string inserted in the target document **210**.

FIG. **11** is an example block diagram of an Extractor **150** creating a target document **820** based on a source document **810** according to embodiments herein. As illustrated in FIG. **11**, the Extractor **150** receives a source document **810** with strings organized within columns breaks.

As shown in FIG. **12**, the Extractor **150** produces a target document **820** that organizes the strings from the source document **810** according to a reading order—but without any of the column breaks.

FIG. **13** is an example block diagram of a document tree **910** with nodes **920** that correspond to logical sections of a target document **820** according to embodiments herein. For example, the document tree **910** includes a node **920-1** that corresponds to a title heading of the target document **910**. Another **920-2** corresponds to text that represents the first name of an author in an author section of the target document **820**. It is understood that the document tree **910** can have multiple various nodes for many types of logical sections of the target document **820**, such as "author department," "abstract," "session," "keywords," etc.

Each node **920** stores an extraction rule(s) that describes semantic entities that are to be extracted from the target document **820** and inserted into a position within a data structure—where the position in the data structure is associated with a particular node **920**.

FIG. **14** is an example block diagram of semantic entities extracted from a target document **820** and inserted into a data structure position that corresponds with a node **920** of a document tree **910** according to embodiments herein.

The Extractor **150** scans the target document **820** to identify a string(s) in the target document **820** that correspond to a semantic entity described by node extraction rules. For example, a "title" node **920-1** describes an extraction rule for extracting "Towards Task-based Personal Information Management Evaluations" from the target document **820**. Upon identifying "Towards Task-based Personal Information Management Evaluations" as a semantic entity, the Extractor **150** inserts "Towards Task-based Personal Information Management Evaluations" into a position **920-1-1**, within in a data structure **1110**, that corresponds with the "title" node **920-1**.

In another example, the "first name" node **920-2** describes an extraction rule for extracting "David" from the target document **820**. Upon identifying "David" as a semantic entity, the Extractor **150** inserts "David" into a position **920-2-1**, within in the data structure **1110**, that corresponds with the "first name" node **920-2**.

FIG. **15** is an example block diagram of an output file of tagged semantic entities according to embodiments herein. The Extractor **150** collects each semantic entity stored in the data structure **1110** and associates a tag with each collected semantic entity. A tag describes a category of content that is specific to a logical section of the target document **820** that includes the collected semantic entity. For example, the Extractor **150** associates a "DOC_TITLE" tag with the semantic entity of "Towards Task-based Personal Information Management Evaluations" from position **920-1-1** in the data structure **1110**. Further, the Extractor **150** associates a "DOC_AUTHOR" tag with the semantic entity of "David" from position **920-2-1** in the data structure **1110**. The Extractor **150** thereby creates an output file **1210** that includes each collected semantic entity and each tag.

FIG. **16** is an example block diagram illustrating an architecture of a computer system **110** that executes, runs, interprets, operates or otherwise performs an Extractor application **150-1** and/or Extractor process **150-2** (e.g. an executing version of an Extractor **150** as controlled or configured by user **108**) according to embodiments herein.

Note that the computer system **110** may be any type of computerized device such as a personal computer, a client computer system, workstation, portable computing device, console, laptop, network terminal, etc. This list is not exhaustive and is provided as an example of different possible embodiments.

In addition to a single computer embodiment, computer system **110** can include any number of computer systems in a network environment to carry the embodiments as described herein.

As shown in the present example, the computer system **110** includes an interconnection mechanism **111** such as a data bus, motherboard or other circuitry that couples a memory system **112**, a processor **113**, an input/output interface **114**, and a display **130**. If so configured, the display can be used to present a graphical user interface of the Extractor **150** to user **108**. An input device **116** (e.g., one or more user/developer controlled devices such as a keyboard, mouse, touch pad, etc.) couples to the computer system **110** and processor **113** through an input/output (I/O) interface **114**. The computer system **110** can be a client system and/or a server system. As mentioned above, depending on the embodiment, the Extractor application **150-1** and/or the Extractor process **150-2** can be distributed and executed in multiple nodes in a computer network environment or performed locally on a single computer.

During operation of the computer system **110**, the processor **113** accesses the memory system **112** via the interconnect **111** in order to launch, run, execute, interpret or otherwise perform the logic instructions of the Extractor application **150-1**. Execution of the Extractor application **150-1** in this manner produces the Extractor process **150-2**. In other words, the Extractor process **150-2** represents one or more portions or runtime instances of the Extractor application **150-1** (or the entire application **150-1**) performing or executing within or upon the processor **113** in the computerized device **110** at runtime.

The Extractor application **150-1** may be stored on a computer readable medium (such as a floppy disk), hard disk, electronic, magnetic, optical, or other computer readable medium. It is understood that embodiments and techniques discussed herein are well suited for other applications as well.

Those skilled in the art will understand that the computer system **110** may include other processes and/or software and hardware components, such as an operating system. Display **130** need not be coupled directly to computer system **110**. For example, the Extractor application **150-1** can be executed on a remotely accessible computerized device via the communication interface **115**.

FIG. **17** through FIG. **20** illustrate various embodiment of the Extractor **150**. The rectangular elements in flowcharts **1400**, **1500**, **1600**, **1700** denote "processing blocks" and represent computer software instructions or groups of instructions upon a computer readable medium. Additionally, the processing blocks represent steps performed by hardware such as a computer, digital signal processor circuit, application specific integrated circuit (ASIC), etc.

Flowcharts **1400**, **1500**, **1600**, **1700** do not necessarily depict the syntax of any particular programming language. Rather, flowcharts **1400**, **1500**, **1600**, **1700** illustrate the functional information one of ordinary skill in the art requires to fabricate circuits or to generate computer software to perform the processing required in accordance with the present invention.

It will be appreciated by those of ordinary skill in the art that unless otherwise indicated herein, the particular sequence of steps described is illustrative only and may be varied without departing from the spirit of the invention. Thus, unless otherwise stated, the steps described below are unordered, meaning that, when possible, the steps may be performed in any convenient or desirable order.

FIG. **17** is a flowchart **1400** of an example of processing steps performed by the Extractor **150** to extract semantic entities from a target document according to embodiments herein.

At step **1410**, the Extractor **150** receives a collection of strings and a bounding box for each string. Each bounding box describes a position of at least a portion of a corresponding string in a source document, which includes multiple sections for presenting portions of the collection of strings

At step **1420**, the Extractor **150** determines string densities occurring in vertical portions of the source document by processing vertical position information from the bounding boxes.

At step **1430**, the Extractor **150** determines string densities occurring in horizontal portions of the source document by processing horizontal position information from the bounding boxes.

At step **1440**, the Extractor **150** detects the section boundaries of the multiple sections in the source document by concurrently analyzing the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions.

At step **1450**, the Extractor **150** builds a target document map segmented according to the section boundaries.

At step **1460**, the Extractor **150** arranges the collection of strings according to a reading order that corresponds to a language associated with the collection of strings.

At step **1470**, upon arranging the collection of strings according to the reading order, the Extractor **150** extracts semantic entities from the collection of strings ordered according to the reading order in a target document.

FIG. **18** is a flowchart **1500** of an example of processing steps performed by the Extractor to identify section indications and sub-section indications amongst string densities occurring in vertical and horizontal portions of a source document according to embodiments herein.

At step **1510**, the Extractor **150** identifies a first section indication amongst the string densities occurring in the vertical portions. In order to identify the first section indication, the Extractor **150** locates a continuously straight span amongst the string densities occurring in the vertical portions that represents an absence of strings.

Upon determining the continuously straight span comprises a width that is greater than a character width associated with at least one of: (i) a string density positioned before the span and (ii) a string density positioned after the first span, the Extractor **150** identifies the continuously straight span as a candidate section boundary. To locate the continuously straight span, the Extractor **150** defines a threshold that describes an allowable amount of string density in the continuously straight span and determines that the actual amount of string density occurring in the continuously straight span is no more than the threshold.

However, upon determining the continuously straight span comprises a width that is less than the character width associated with at least one of: (i) the string density positioned before the first span and (ii) the string density positioned after the first span, the Extractor **150** identifies the continuously straight span as an invalid span.

At step **1520**, the Extractor **150** identifies a second section indication amongst the string densities occurring in the horizontal portions by locating a continuously straight span amongst the string densities occurring in the horizontal portions that represents an absence of strings.

Upon determining that that continuously straight span comprises a height that is greater than a character height associated with at least one of: (i) a string density positioned before the continuously straight span and (ii) a string density positioned after the continuously straight span, the Extractor **150** identifies the continuously straight span as a candidate section boundary. To locate the continuously straight span, the Extractor **150** defines a threshold that describes an allowable amount of string density in the continuously straight span and determines that the actual amount of string density occurring in the continuously straight span is no more than the threshold.

However, upon determining that the continuously straight span comprises a height that is less than the character height associated with at least one of: (i) the string density positioned before the second continuously straight span and (ii) the string density positioned after the second continuously straight span, the Extractor **150** identifies the continuously straight span as an invalid span.

At step **1530**, the Extractor **150** compares the first section indication and the second section indication.

At step **1540**, based on a comparison between the first section indication and the second section indication, the Extractor **150** identifies a widest section indication.

At step **1550**, the Extractor **150** identifies the position of the widest section indication as a section boundary in the target document map.

At step **1560**, with respect to vertical portions and horizontal portions that occur before the position of the widest section, the Extractor **150** repeats steps **1440** and **1510** in order to identify a first sub-section boundary.

At step **1570**, with respect to vertical portions and horizontal portions that occur after the position of the widest section, the Extractor **150** repeats steps **1440** and **1510** in order to identify a second sub-section boundary.

FIG. **19** is a flowchart **1600** of an example of processing steps performed by the Extractor to arrange areas within target document map according to a reading order according to embodiments herein.

At step **1610**, the Extractor **150** defines a character spacing threshold describing an amount of allowable spacing between two string characters.

At step **1620**, the Extractor **150** defines a string spacing threshold describing an amount of spacing between two strings.

At step **1630**, the Extractor **150** identifies areas in the target document map that are framed section boundaries.

At step **1640**, based on a position of each area of the target document map, the Extractor **150** arranges each area to support the reading order.

At step **1650**, the Extractor **150** arranges each area such that a first ordered area comprises a left-most and top-most area from the target document map and a last ordered area comprises a right-most and bottom-most area from the target document map.

At step **1660**, for each area of the target document, the Extractor **150** identifies each bounding box that maps to an the area. Upon identifying the bounding box, the Extractor **150** identifies a previous bounding box with respect to the position of the identified bounding box. If a spacing between the identified bounding box and the previous bounding box is within the character spacing threshold, the Extractor **150** combines the identified bounding box and the previous bounding box to form a complete string (i.e. a single string).

If the spacing between the identified bounding box and the previous bounding box is at least equal to the string spacing threshold, the Extractor **150** includes a space between the identified bounding box and the previous bounding box.

The Extractor **150** arranges each bounding box that maps within the area according to the reading order. To do so, the Extractor **150** determines a first bounding box as a bounding box positioned at a left-most and top-most coordinate within the area and a last bounding box as a bounding box positioned at a right-most and left-most coordinate with the area. The Extractor **150** similarly arranges all other bounding boxes according to the reading order between the first bounding box and last bounding box. The Extractor **150** then inserts string content from each string associated with the bounding box into the target document according to the reading order.

FIG. **20** is a flowchart **1700** of an example of processing steps performed by the Extractor to create an output file with semantic entities and tags for each semantic entity according to embodiments herein.

At step **1710**, the Extractor **150** utilizes a document tree that includes nodes corresponding to logical sections of the target document. The nodes each store an extraction rule describing semantic entities to be extracted from the target document and placed at a position within a data structure. Each position in the data structure is associated with a node in the document tree.

At step **1720**, the Extractor **150** scans the target document to identify a string in the target document that corresponds to a semantic entity described by an extraction rule at one of the nodes.

At step **1730**, upon identifying the string that corresponds to the semantic entity, the Extractor **150** inserts the identified string into the position in the data structure.

At step **1740**, the Extractor **150** collects each semantic entity stored in the data structure.

At step **1750**, for each collected semantic entity, the Extractor **150** associates a tag to a collected semantic entity (See step **1760**) The tag describes a category of content, for the collected semantic entity, specific to a logical section of the target document that includes the collected semantic entity.

At step **1770**, the Extractor **150** creates an output file that includes each collected semantic entity and each tag.

The methods and systems described herein are not limited to a particular hardware or software configuration, and may find applicability in many computing or processing environments. The methods and systems may be implemented in hardware or software, or a combination of hardware and software. The methods and systems may be implemented in one or more computer programs, where a computer program may be understood to include one or more processor executable instructions. The computer program(s) may execute on one or more programmable processors, and may be stored on one or more storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), one or more input devices, and/or one or more output devices. The processor thus may access one or more input devices to obtain input data, and may access one or more output devices to communicate output data. The input and/or output devices may include one or more of the following: Random Access Memory (RAM), Redundant Array of Independent Disks (RAID), floppy drive, CD, DVD, magnetic disk, internal hard drive, external hard drive, memory stick, or other storage device capable of being accessed by a processor as provided herein, where such aforementioned examples are not exhaustive, and are for illustration and not limitation.

The computer program(s) may be implemented using one or more high level procedural or object-oriented programming languages to communicate with a computer system; however, the program(s) may be implemented in assembly or machine language, if desired. The language may be compiled or interpreted.

As provided herein, the processor(s) may thus be embedded in one or more devices that may be operated independently or together in a networked environment, where the network may include, for example, a Local Area Network (LAN), wide area network (WAN), and/or may include an intranet and/or the internet and/or another network. The network(s) may be wired or wireless or a combination thereof and may use one or more communications protocols to facilitate communications between the different processors. The processors may be configured for distributed processing and may utilize, in some embodiments, a client-server model as needed. Accordingly, the methods and systems may utilize multiple processors and/or processor devices, and the processor instructions may be divided amongst such single- or multiple-processor/devices.

The device(s) or computer systems that integrate with the processor(s) may include, for example, a personal computer(s), workstation(s) (e.g., Sun, HP), personal digital assistant(s) (PDA(s)), handheld device(s) such as cellular telephone(s), laptop(s), handheld computer(s), or another device(s) capable of being integrated with a processor(s) that may operate as provided herein. Accordingly, the devices provided herein are not exhaustive and are provided for illustration and not limitation.

References to "a processor", or "the processor," may be understood to include one or more microprocessors that may communicate in a stand-alone and/or a distributed environment(s), and may thus be configured to communicate via wired or wireless communications with other processors, where such one or more processor may be configured to operate on one or more processor-controlled devices that may be similar or different devices. Use of such "processor" terminology may thus also be understood to include a central processing unit, an arithmetic logic unit, an application-specific integrated circuit (IC), and/or a task engine, with such examples provided for illustration and not limitation.

Furthermore, references to memory, unless otherwise specified, may include one or more processor-readable and accessible memory elements and/or components that may be internal to the processor-controlled device, external to the processor-controlled device, and/or may be accessed via a wired or wireless network using a variety of communications protocols, and unless otherwise specified, may be arranged to include a combination of external and internal memory devices, where such memory may be contiguous and/or partitioned based on the application.

References to a network, unless provided otherwise, may include one or more intranets and/or the internet, as well as a virtual network. References herein to microprocessor instructions or microprocessor-executable instructions, in accordance with the above, may be understood to include programmable hardware.

Throughout the entirety of the present disclosure, use of the articles "a" or "an" to modify a noun may be understood to be used for convenience and to include one, or more than one of the modified noun, unless otherwise specifically stated.

Elements, components, modules, and/or parts thereof that are described and/or otherwise portrayed through the figures to communicate with, be associated with, and/or be based on, something else, may be understood to so communicate, be associated with, and or be based on in a direct and/or indirect manner, unless otherwise stipulated herein.

Although the methods and systems have been described relative to a specific embodiment thereof, they are not so limited. Obviously many modifications and variations may become apparent in light of the above teachings. Many additional changes in the details, materials, and arrangement of parts, herein described and illustrated, may be made by those skilled in the art.

What is claimed is:

1. A method comprising:

receiving a collection of strings, each string from the collection of strings having a corresponding bounding box describing a position of at least a portion of the string in a source document, the source document including multiple sections, each section presenting at least a portion of the collection of strings;

determining string densities occurring in a first subset of vertical portions of the source document by processing vertical position information from at least one bounding box by scanning left to right;

determining string densities occurring in a first subset of horizontal portions of the source document by processing horizontal position information from at least one bounding box by scanning top to bottom;

detecting a section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in vertical portions and the string densities occurring in horizontal portions;

based on the section boundary, assigning each string from the collection of strings to either a pre-boundary collection of strings, or a post-boundary collection of strings;

recursively analyzing the pre-boundary collection of strings and the post-boundary collection of strings to search for additional section boundaries in each collection; and

arranging the collection of strings according to a reading order using the section boundary, the reading order corresponding to a language associated with the collection of strings.

2. The method as in claim **1**, wherein detecting the section boundary further comprises using both the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions; and wherein the method further comprises building a target document map segmented according to the section boundary.

3. The method as in claim 2, wherein detecting the section boundary comprises:

identifying a first section indication amongst the string densities occurring in the vertical portions;

identifying a second section indication amongst the string densities occurring in the horizontal portions;

comparing the first section indication and the second section indication;

based on a comparison between the first section indication and the second section indication, identifying a widest section indication; and

identifying a position of the widest section indication as the section boundary in the target document map.

4. The method as in claim 3 wherein recursively analyzing the pre-boundary collection of strings comprises:

determining subsection string densities occurring in a second set of vertical portions of the source document before the section boundary by processing vertical position information from at least one bounding box by scanning left to right;

determining subsection string densities occurring in a second set of horizontal portions of the source document before the section boundary by processing horizontal position information from the at least one bounding box by scanning top to bottom;

detecting a second section boundary in the source document using the subsection string densities occurring in vertical portions and the subsection string densities occurring in horizontal portions.

5. The method as in claim 3, wherein identifying the first section indication amongst the string densities occurring in the vertical portions includes:

locating a first continuously straight span amongst the string densities occurring in the vertical portions that represents an absence of strings;

upon determining the first continuously straight span comprises a width greater than a character width associated with at least one of: (i) a string density positioned before the first span and (ii) a string density positioned after the first span, identifying the first continuously straight span as a candidate section boundary; and

upon determining the first continuously straight span comprises a width less than the character width associated with at least one of: (i) the string density positioned before the first span and (ii) the string density positioned after the first span, identifying the first continuously straight span as an invalid span.

6. The method as in claim 5, wherein locating the first continuously straight span amongst the string densities occurring in the vertical portions includes:

defining a first threshold describing an allowable amount of string density in the first continuously straight span; and

determining an amount of string density occurring in the first continuously straight span is no more than the first threshold.

7. The method as in claim 3, wherein identifying the second section indication amongst the string densities occurring in the horizontal portions includes:

locating a second continuously straight span amongst the string densities occurring in the horizontal portions that represents an absence of strings;

upon determining the second continuously straight span comprises a height greater than a character height associated with at least one of: (i) a string density positioned before the second continuously straight span and (ii) a string density positioned after the second continuously straight span, identifying the second continuously straight span as a candidate section boundary; and

upon determining the second continuously straight span comprises a height less than the character height associated with at least one of: (i) the string density positioned before the second continuously straight span and (ii) the string density positioned after the second continuously straight span, identifying the second continuously straight span as an invalid span.

8. The method as in claim 7, wherein locating the second continuously straight span amongst the string densities occurring in the horizontal portions includes:

defining a second threshold describing an allowable amount of string density in the second continuously straight span; and

determining an amount of string density occurring in the second continuously straight span is no more than the second threshold.

9. The method as in claim 1, comprising:

detecting at least one indication of a vertical section in the source document among the string densities occurring in the vertical portions, the at least one indication of the vertical section in the source document comprising a width greater than a character width of at least one string proximate to the at least one indication of the vertical section; and

detecting at least one indication of a horizontal section in the source document among the string densities occurring in the horizontal portions, the at least one indication of the horizontal section in the source document comprising a height greater than a character height of at least one string proximate to the at least one indication of the horizontal section.

10. A non-transitory computer readable medium comprising executable instructions encoded thereon operable on a computerized device to perform processing comprising:

instructions for receiving a collection of strings, each string from the collection of strings having a corresponding bounding box describing a position of at least a portion of the string in a source document, the source document including multiple sections, each section for presenting at least a portion of the collection of strings;

instructions for determining string densities occurring in a first subset of vertical portions of the source document by processing vertical position information from at least one bounding box;

instructions for determining string densities occurring in a first subset of horizontal portions of the source document by processing horizontal position information from at least one bounding box;

instructions for detecting a section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions;

instructions for assigning, based on the section boundary, each string from the collection of string to either a pre-boundary collection of string, or a post-boundary collection of strings;

instructions for recursively analyzing the pre-boundary collection of strings and the post-boundary collection of strings; and instructions for building a target document map segmented according to the section boundary.

11. The non-transitory computer readable medium in claim **10**, wherein the instructions for detecting the section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions include:

instructions for identifying a first section indication amongst the string densities occurring in the vertical portions;

instructions for identifying a second section indication amongst the string densities occurring in the horizontal portions;

instructions for comparing the first section indication and the second section indication;

instructions for identifying a widest section indication based on a comparison between the first section indication and the second section indication; and

instructions for identifying a position of the widest section indication as a section boundary in the target document map.

12. The non-transitory computer readable medium as in claim **11**, comprising:

with respect to vertical portions and horizontal portions that occur before the position of the widest section, repeating the instructions for detecting the at least one section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions in order to identify a first sub-section boundary; and

with respect to vertical portions and horizontal portions that occur after the position of the widest section, repeating the instructions for detecting the at least one section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in the vertical portions and the string densities occurring in the horizontal portions in order to identify a second sub-section boundary.

13. The non-transitory readable medium as in claim **11**, wherein instructions for identifying the first section indication amongst the string densities occurring in the vertical portions include:

instructions for locating a first continuously straight span amongst the string densities occurring in the vertical portions that represents an absence of strings;

instructions for identifying the first continuously straight span as a candidate section boundary upon determining the first continuously straight span comprises a width greater than a character width associated with at least one of: (i) a string density positioned before the first span and (ii) a string density positioned after the first span; and

instructions for identifying the first continuously straight span as an invalid span upon determining the first continuously straight span comprises a width less than the character width associated with at least one of: (i) the string density positioned before the first span and (ii) the string density positioned after the first span.

14. The non-transitory readable medium as in claim **13**, wherein the instructions for locating the first continuously straight span amongst the string densities occurring in the vertical portions include:

instructions for defining a first threshold describing an allowable amount of string density in the first continuously straight span; and

instructions for determining an amount of string density occurring in the first continuously straight span is no more than the first threshold.

15. The non-transitory readable medium as in claim **11**, wherein instructions for identifying the second section indication amongst the string densities occurring in the horizontal portions include:

instructions for locating a second continuously straight span amongst the string densities occurring in the horizontal portions that represents an absence of strings;

instructions for identifying the second continuously straight span as a candidate section boundary upon determining the second continuously straight span comprises a height greater than a character height associated with at least one of: (i) a string density positioned before the second continuously straight span and (ii) a string density positioned after the second continuously straight span; and

instructions for identifying the second continuously straight span as an invalid span upon determining the second continuously straight span comprises a height less than the character height associated with at least one of: (i) the string density positioned before the second continuously straight span and (ii) the string density positioned after the second continuously straight span.

16. The non-transitory readable medium as in claim **15**, wherein the instructions for locating the second continuously straight span amongst the string densities occurring in the horizontal portions include:

instructions for defining a second threshold describing an allowable amount of string density in the second continuously straight span; and

instructions for determining an amount of string density occurring in the second continuously straight span is no more than the second threshold.

17. A computer system comprising:

a processor;

a memory unit that stores instructions associated with an application executed by the processor; and

an interconnect coupling the processor and the memory unit, enabling the computer system to execute the application and perform operations of:

receiving a collection of strings, each string from the collection of strings having a corresponding bounding box describing a position of at least a portion of the string in a source document, the source document including multiple sections, each section for presenting at least a portion of the collection of strings;

determining string densities occurring in a first subset of vertical portions of the source document by processing vertical position information from at least one bounding box by scanning left to right;

determining string densities occurring in a first subset of horizontal portions of the source document by processing horizontal position information from at least one bounding box by scanning top to bottom;

detecting a section boundary of one of the multiple sections in the source document by concurrently analyzing the string densities occurring in vertical portions and the string densities occurring in horizontal portions;

assigning, based on the section boundary, each string from the collection of string to either a pre-boundary collection of string, or a post-boundary collection of strings;

recursively analyzing the pre-boundary collection of strings and the post-boundary collection of strings; and

arranging the collection of strings according to a reading order, the reading order corresponding to a language associated with the collection of strings.

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